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PROCEEDINGS OF THE AMERICAN SOCIETY OF ZOÖLOGISTS.

FIRST ANNUAL MEETING OF THE EASTERN BRANCH.

THE first annual meeting of the Eastern Branch of the American Society of Zoölogists, the fourteenth annual meeting of the Society since its establishment as the American Morphological Society, was held in Biological Hall, University of Pennsylvania, Philadelphia, Pa., on Tuesday and Wednesday, December 29 and 30, 1903.

In accordance with the report of the committee appointed at the preceding meeting to consider the matter of the publication of the proceedings of the Society, of an official organ, etc., it was voted to be the sense of the Eastern Branch of the American Society of Zoölogists that the *American Naturalist* should become the official organ of the Society, and the committee was empowered to arrange for the publication of this year's proceedings of the Eastern Branch in the *American Naturalist.*

The committee in charge of the preparation of an invitation to the International Zoölogical Congress to hold its meeting in 1907 in America, presented its report, which was adopted. As the result of this action, and similar action by the Central

Branch, the American Society of Zoölogists will invite the International Zoölogical Congress to meet in America in 1907. The necessary preliminary arrangements have been left to a committee. The committee appointed to draw up a definition of zoölogical requirements for admission to college, conformable with the definition of the requirements in other sciences, published by the College Entrance Examination Board, submitted a report of progress that caused considerable discussion, and the committee was continued.

The list of officers for 1904 is as follows:

President, E. A. Andrews; vice-president, W. E. Castle; secretary-treasurer, G. A. Drew. Additional members of the executive committee, T. H. Montgomery, Jr., H. C. Bumpus, H. S. Jennings.

The following are abstracts of papers presented at the meeting:

The Egg Cases of Chimæroid Fishes: Bashford Dean, Columbia University. — The egg cases of chimæroid fishes present an extreme case of adaptation, not to the egg of the time it is placed in the capsule, but to the young fish when about to escape. From this standpoint the capsule is adapted in the matter of extreme size, definite modeling to the head, trunk and tail of the young fish, durability, mode of attachment, position, which enables the young fish to develop dorsal side upward, orientation, wherein the snout of the young fish develops in the direction of the opening valve, and the tail in the direction of the long and narrow end of the capsule. Further adaptations include an elaborate provision for circulation of water within the capsule, the mechanism for which improves as the embryo develops, by means of a process of weathering, whereby the perforations of the capsule become progressively larger; and a special exit valve which can be opened only from within, and only at the time when the fish is ready to escape. The exit valve has then a kind of tension resulting in "dehiscence," comparable somewhat to that of the elements of a seed pod. Adaptation is made still more complete by provision for the specific characters of the adult; thus the species which have the longest tails have the

longest tail sheaths in the egg capsules, and those having the deepest bodies have also the deepest cavity in the main portion of the capsule.

The foregoing characters evidently cannot be explained by the Lamarckian hypothesis, for so perfect a case could not have been formed primitively *in utero* around the embryo; for, by the principle of use and disuse itself, such an elaborate capsule would not have been formed for the protection of an embryo which was just about to be hatched, nor would the capsule be provided for aquatic breathing. It is, moreover, a well known law that in uterine development the secondary membranes are reduced rather than increased. Natural selection, as it is generally understood, is equally inadequate to explain the formation of the present capsule; for, from this standpoint, fluctuating variations would have had to be selected throughout a long series of complicated changes in two entirely different lines, *i. e.*, in the line of the evolution of the embryo and in that of the evolution of the capsule. And it is more than difficult to imagine that in each of these parallel series the corresponding favorable fluctuations could have continued to be successively selected. This series of constantly adapted stages furnishes a notable example of development in a definite line.

The Reproductive Organs of the Limbless Lizard Anniella: W. R. Coe and B. W. Kunkel, Yale University.— The subject of this investigation, *Anniella pulchra*, lives on the barren sand plains in certain portions of California and Arizona. It is a slender, worm-like lizard, entirely devoid of limbs and limb girdles except for slight rudiments of the pelvic arch. It lives beneath the surface of the sand and feeds upon small insects and spiders.

Although described in 1852, it has never been carefully studied except with regard to its external anatomy and skeleton.

An examination of its viscera reveals a number of interesting anatomical peculiarities, among which those of the reproductive organs are perhaps the most striking. These relate particularly to the oviducts and uterus of the female and the copulatory organs of the male.

As in many other lizards, Anniella is ovoviviparous. The young, only two of which are produced in a season, are born in

September. Both of these develop in the right oviduct (Fig. 1, *ut, ut'*), the left being very rudimentary and apparently quite functionless (Fig. 1, *l. od*). The right and left ovaries are equally well developed and a single ovum matures in each, but both ova enter the right oviduct.

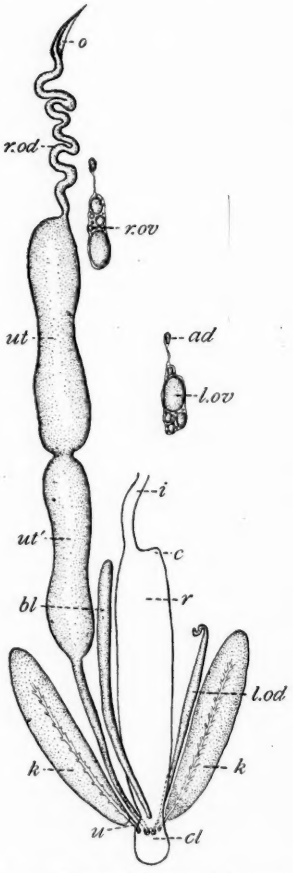


FIG. 1.—Diagram of the urogenital organs of Anniella, showing the right oviduct (*r. od*) with the two developing embryos (*ut, ut'*) in the uterus, the rudimentary left oviduct (*l. od*), and the ovaries (*l. ov* and *r. ov*); *ad*, adrenal body; *o*, ostium of right oviduct; *bl*, urinary bladder; *k*, kidney; *u*, ureter; *cl*, cloaca; *i*, ileum; *c*, rudimentary cæcum; *r*, rectum. × 3.

The rudimentary left oviduct is represented by a slender tube usually extending forward only about as far as the anterior ends of the kidneys, which are situated in the most posterior portion of the body cavity (Fig. 1, *l. od*). The anterior end of this aborted oviduct is terminated by a very narrow canal which usually shows a tendency to become more or less convoluted. It is especially noteworthy that this convoluted, terminal canal shows great variation in length in different individuals. In a single specimen examined it was about half as long as that of the functional right oviduct. In this single instance the rudimentary oviduct is terminated anteriorly by an ostium opening into the body cavity. The posterior end of the left oviduct is but little smaller than that of the right, and has a similar structure and similar relations with the cloaca.

These peculiarities furnish a striking example of what appears to be a very recently acquired anatomical character — one which

has not reached a condition of stable equilibrium, as instanced by the great variation of the parts concerned. The left oviduct has apparently been eliminated as a functional organ of the body, and yet the case mentioned where it was half as long as the functional one suggests the possibility of further variations, which, in an exceptional case, might show a reversion to the primitive condition in which an embryo might develop in this now rudimentary organ.

So far as we are aware no instance of an aborted and functionless oviduct has been reported for any of the lizards. The related genus, Anguis, of Europe, has both oviducts well developed. In many reptiles, however, the left is shorter than the right oviduct, so that Anniella presents a variation along the same line as these other reptiles, but one which has been carried to an extreme condition.

It should be pointed out that it is the left oviduct which is aborted in Anniella, while it is the right which has become functionless in birds. In the latter, however, the degeneration of the parts is carried to a greater length in that the right ovary is

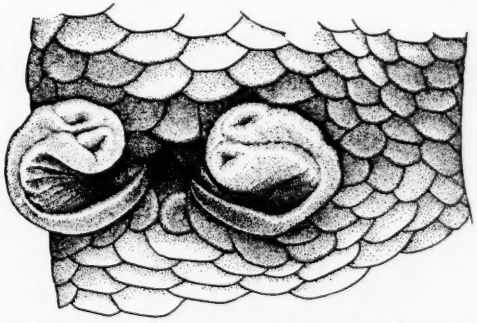


FIG. 2.— Portion of ventral surface of embryo of Anniella shortly before birth, showing the pair of large copulatory organs (phalli) projecting from the lateral borders of the cloacal aperture and the oblique groove and terminal pits with which each phallus is provided. × 22.

likewise more or less aborted, while in Anniella both ovaries retain their normal functions.

In the male the spermaries and the sperm ducts are developed equally on the two sides of the body. The copulatory organs (phalli) are formed as finger-like, external projections from the

lateral borders of the cloacal aperture, and nearly to the time of birth have a curious resemblance to a pair of rudimentary limbs (Fig. 2). Shortly before birth they are drawn into the cloacal aperture, and by a process of invagination are converted into a pair of slender pouches which extend backward into the caudal region for a considerable distance behind the cloaca. They then lie on the ventral side of the tail and immediately internal to the muscles of the integument.

It is a remarkable fact that these copulatory organs develop in females as well as in males. In females, however, they cease their development after they are converted into post-cloacal pouches, although they are retained throughout the life of the animal. In the males, on the other hand, they increase greatly in size at the time of sexual maturity. During the act of copulation the large blood sinuses with which they are provided become distended with blood. This surcharging with blood, together with the contraction of certain muscles which surround the pouches, causes the phalli to be everted to their original, embryonic condition, and thus to function as a pair of true copulatory appendages.

Some Account of the Temporary Biological Station at Bermuda for the Season of 1903: Charles L. Bristol, New York University.— The following invitation was issued about May 1, 1903:

Harvard University and New York University unite with the Bermuda Natural History Society in inviting botanists and zoölogists to spend six weeks in the temporary biological station provided for the present season at Bermuda.

By special arrangements with the Quebec S. S. Co. and the Hotel Frascati it has been possible to make the total expense, including transportation from New York and return, and board and lodging for six weeks at Bermuda, one hundred dollars.

The Bermuda Natural History Society has expressed its intention to do everything in its power to make the summer's work as profitable and pleasurable as possible, and to this end has undertaken to provide, among other things, the necessary facilities for collecting, namely, a steam launch, thirty to forty feet long, with crew; a sail boat with fish-well and crew; three rowing

boats, and a carriage with two horses, capable of carrying ten or twelve persons. The laboratory will be equipped with all necessary reagents and utensils except microscopes and dissecting instruments, which should be brought by each investigator.

The well known richness of the sub-tropical fauna and flora, the healthfulness and equable temperature of the islands, and the ease with which they may be reached combine to make the Bermudas a most attractive field for biological research.

Venerable George Tucker, Archdeacon, President Bermuda Natural History Society.

Hon. W. Maxwell Green, Consul U. S. A., Vice-president B. N. H. S.

F. Goodwin Gosling, Honorary Secretary B. N. H. S.

E. L. Mark, Director of Zoölogical Laboratory, Harvard University.

C. L. Bristol, Professor of Biology, New York University.

It met with a hearty reception, and in response to it thirty-three botanists and zoölogists from widely scattered portions of the United States availed themselves of the opportunity offered. The committee in charge was somewhat embarrassed at first, as our temporary laboratory was equipped for twenty research students, but the proprietor of the Hotel Frascati kindly gave up two large rooms in the hotel so that all were comfortably cared for.

The facilities provided and paid for by the Bermuda Natural History Society enabled the party to make daily excursions either by launch to the reefs and lagoons, by wagons to botanical collecting localities, or by rowboat to the nearby places.

During the season Capt. W. E. Myers of St. George placed his powerful sea-going tug, "Gladisfen," at the disposal of the expedition to collect on the "Challenger" bank. The trip occupied three days and was very fruitful in results.

During the stay of the party, between June 22 and August 22, the weather was pleasant save one or two days of dead calm, when it was disagreeably warm, though at no time did the thermometer go above 85° F. The general health of the party was excellent, and demonstrates what my experience had led me to believe, — that the climate is favorable for college workers in midsummer.

The accommodations at Hotel Frascati were excellent. Our party so nearly filled the house that the proprietor, Mr. Alonzo Peniston, put it practically at our disposal, accommodating his meals to our excursions whenever it was desired. The table was first-class, and not to be compared with the usual summer board at seaside laboratories. The food was well cooked, was abundant, and well served at tables always decked with a profusion of flowers.

The party was welcomed on its arrival at the dock by the venerable Archdeacon Tucker, Hon. W. Maxwell Greene and Mr. F. Goodwin Gosling, and this welcome was continued by every one — high and low — during the season. His Excellency, the Governor, Gen. H. LeG. Geary, was kind enough to extend a hearty welcome to the party by holding a reception at Mt. Langton, to which nearly two hundred guests were invited. Hospitality was extended on all sides, and almost to the embarrassment of the work at times.

The people of Bermuda became interested in the annual visits of the New York University Biological Expeditions from 1897 to 1902, and in 1902 a committee of the Legislature was appointed to consider and report on the advisability of the establishment of a Marine Biological Station. The Colonial Secretary, by direction of His Excellency the Governor, addressed a letter asking for information and coöperation to the following: the British Association for the Advancement of Science, the Carnegie Institution, the Royal Society, the Minister of Marine and Fisheries, Canada, Dr. Auton Dohrn, Naples. The responses were all heartily in favor of the idea, and this encouraged His Excellency to ask the approval of the Imperial Government. This was granted in a despatch from the then Secretary of State for the Colonies, Hon. Joseph Chamberlain, and the way was clear for further action by the Colony. In November, 1903, Governor Geary sent a message to the House of Assembly which has resulted in appropriate legislation without a dissenting voice.

It may be safely said now that before long a well equipped station will be available for biologists at Bermuda that will be open the year round.

During the coming summer another "temporary" station

will be established and good facilities offered for advanced workers.

A Key to the Development of Sipunculus nudus[1]*:* John H. Gerould, Dartmouth College.— The development of Phascolosoma shows that the embryonal envelope or serosa of *Sipunculus nudus*, described by Hatchek, is a modified prototroch. In the gastrula stage of each form the prototroch consists of two or three rows of broad, flat cells which encircle the embryo. In the trochophore of *Ph. vulgare* the apical plate, the mid-dorsal cord of ectoderm in the interruption of the prototroch and the somatic plate are strikingly similar to the corresponding parts in *S. nudus*, but in the former no sinking beneath the vitelline membrane occurs, and no amniotic cavities are formed. The resemblance between the trochophores extends even to the apical rosette and to the cells which bear the postoral circlet of cilia.

The remnants of the prototroch of Sipunculus are cast off with the vitelline membrane, the huge prototroch cells of Phascolosoma degenerate during metamorphosis, and their substance in the form of yolk granules passes backward into the newly formed cœlom. Thus the cœlom of the larva becomes filled with yolk granules, which Selenka mistook for blood corpuscles. These gradually are absorbed. A cuticula is formed beneath the vitelline membrane, the latter is shed, and an overgrowth of the region vacated by the prototroch cells takes place.

Sipunculids are primitive Trochozoa, closely allied to chætopods. The adult sipunculid retains the retractor muscles and nephridia of the trochophore; and the loss of the prototroch, development of the cœlom and elongation of the trunk are the only fundamental changes which the trochophore undergoes in passing into the adult form. Resemblance of the trochophore of Phascolosoma to that of chætopods, *e. g.*, Amphitrite, is striking. Transitory metamerism of the mesoblastic bands and

[1] The reader is referred, for a more complete account, to Studies on the Embryology of the Sipunculidæ. I. The Embryonal Envelope and its Homologue. *Mark Anniversary Volume.* Cambridge, Mass., 1903; and The Development of Phascolosoma (preliminary note). *Archives de Zoöl. expér. et gén. Notes et Revue.* 4e série, T. 2, No. 2, 1904. p. xvii–xxix.

of the fundament of the nerve cord in *Ph. gouldii*, immediately before metamorphosis, points definitely to an intimate relationship between the sipunculids and the annelids. Sipunculus is more highly modified than Phascolosoma.

Divergence Under the Same Environment as Seen in the Hawaiian Snails: John T. Gulick, Oberlin, Ohio.— The Island of Oahu presents two mountain ranges; one near the northeast coast, about 35 miles in length, and enjoying a heavy rainfall, especially on the side of the range most exposed to the northeast trade-winds; the other, near the southwest coast, about half as long, and receiving much less rain. The forest regions on these two mountain ranges are occupied by about 300 species of snails belonging to eight genera of the family Achatinellidæ. A large majority of these species belong to four genera found always on the trees or other vegetation. Auriculella clings to the leaves, is about the size of a grain of wheat, and is represented by one abundant species on the dry mountain range, and by several species on the other range. Apex is from half an inch to an inch in length, and occupies the dry range, and the drier ridges of the other range. Achatinella and Bulimella are in size not very different from Apex, and like it are found on the trunks and branches as well as on the leaves; but their distribution is almost entirely on the longer mountain range, Achatinella being more abundant on the less rainy side, and Bulimella prevailing on the more rainy side.

Natural selection has undoubtedly been an important factor in adapting Bulimella for the rainiest districts; and Achatinella and Bulimella for the shady groves of the less rainy region, and Apex for the driest region as well as for the deficient shade on the ridges of the intermediate region.

But we come now to species whose divergence refuses to be explained by either natural selection or sexual selection. As an example of divergent evolution that must depend on other controlling principles, let us consider the formation of the series of species of Achatinella occupying the valleys on the southwest side of the main mountain range. The temperature, the rainfall, the soil, and the plant and animal species surrounding these snails are much the same.

Commencing at the most eastern of these valleys and proceeding toward the northwest, we find that the first seven or eight miles brings us past about that number of deep valleys, occupied by shady groves and inhabited by many varieties belonging to fifteen or more species. These species are all of the larger type of the genus, being near an inch in length. With some of them, all the individuals of the species are found in the groves of a single valley, and in the case of most, even stragglers are not found at a distance of more than a mile from the metropolis of the species.

Proceeding toward the northwest, we find that the genus is represented by many species, of progressively diminishing size, till at the other end of the mountain range the shells have dimensions not more than half those presented by the shells found in the valleys first explored. The habits of feeding are also wholly different; for as we approach the northwest end of the range we find that the larger trees have been deserted, and the shrubs and herbs have become the homes of most of the species. This diversity either in the inherited aptitudes or in the acquired habits of the isolated groups of one stock, resulting in different methods of dealing with the same environment, undoubtedly results in different forms of selection helping to mould the different groups into different species. We, however, note that, in these cases, the process is not natural selection; for it is not difference in the environment causing the accumulation of divergent adaptations, but it is slightly divergent adaptations, protected by isolation from the swamping effects of free-crossing with the original stock, that initiates divergent methods of dealing with the same environment, and so determines the difference in the selection which emphasizes the divergence. This form of selection, determined by the aptitudes and habitudes of the species in dealing with the environment, I call endonomic selection.

A point of very great interest is the important part filled by isolation in producing divergent forms of endonomic selection. If a pair of individuals from a plastic (or variable) species are completely isolated from the original stock, the probability is that in some way their method of dealing with the environment

will differ from the method prevailing in the original home, though under certain circumstances it may have been tried by some of the original stock. New relations having been established with the environment, and the swamping effect of association and intergeneration being removed, divergent evolution is insured. Two genera of the Achatinellidæ are found almost exclusively on the ground among the dead leaves. The divergence between these genera living on the ground and those living on the trees and shrubs was probably gradually introduced in some such way. In the same way may have arisen the differences between the genus of minute species feeding on the leaves and the genera of larger forms feeding on what is found on the trunks and branches of the trees.

The Function of the Lateral Line Organs in Fishes: G. H. Parker, Harvard University. — This work was carried on at the Biological Laboratory of the United States Bureau of Fisheries at Woods Hole, Massachusetts. Tests were made on smooth dogfish, skates, winter flounders, scup, and two species of Fundulus. The action of the lateral line organs was eliminated by cutting the branches of the fifth, seventh, and tenth nerves supplied to these organs. After recovery from shock the reactions of individuals on which these operations had been carried out were compared with those of normal fishes. No significant differences could be discovered in the reactions of normal and operated fishes to the following stimuli: temperature changes from 9° C. to 30° C.; salinity changes having a range between a mixture of one part sea water and four parts fresh water, and sea water concentrated to three fourths its original volume; reduced oxygen supply; increased carbon dioxide; foul water; reduction of pressure to nine pounds; increase of pressure to twenty-two pounds; and currents of water. On testing for equilibrium it was found that the lateral line organs were of no more significance in this respect than the general integument. Normal and operated fishes did not respond differently to sound vibration of the rate of 100 per second. Operated fishes failed to respond to vibrations at the rate of six per second, whereas normal fishes reacted to these with great precision. The lateral line

organs are, therefore, concerned with vibrations of low frequency. These vibrations are often produced when large objects move in the water or when wind blows on its surface.

The Sexual Elements of the Giant Salamander: Albert M. Reese, Syracuse University. — Eggs and spermatozoa were obtained by stripping giant salamanders (*Cryptobranchus alleghenensis*) during the latter part of September.

Each egg is a spherical mass of yellow yolk, about 6 mm. in diameter, surrounded by two layers of transparent jelly; it does not completely fill the inner envelope, but is surrounded by an aqueous fluid.

The egg proper is filled with yolk granules of various sizes, and is surrounded by a thin vitelline membrane.

The gelatinous envelopes are continued as slender cords from egg to egg, forming a continuous string similar to the egg-strings of Amphiuma. The distance between two adjacent eggs is about four or five times the diameter of a single egg.

Some dozens of eggs were obtained from one female, all of them apparently being derived from one ovary.

The spermatozoa, in which no motion could be seen, though stripped with little difficulty from the males, consist of an elongated, cylindrical nucleus, a sharp, gradually-tapering apical body, and a tail of moderate length which consists of a central fibre and a transparent envelope. No middle-piece can be made out.

Artificial fertilization was attempted but was entirely unsuccessful.

Some Recently Discovered Cases of Mutual Sexual Adaptation: P. P. Calvert, University of Pennsylvania. — In studying the Odonata of Mexico and Central America for the *Biologia Centrali-Americana* it was found that a new species of Protoneura, *P. peramans*, presented a remarkable adaptation of the sexes for mutual grasping during pairing, in that the bifid, superior, terminal, abdominal appendages of the male are received between bifid, mesothoracic processes of the female. The other species of this genus from this region show no (or less perfect) adaptations in this regard.

Segmentation of the Ovum of Desmognathus fusca:[1] William A. Hilton, Cornell University. — During the last few years several amphibian eggs have been found which, from the few stages of development described, seem to indicate a meroblastic rather than a holoblastic method of cleavage. The first of these was reported by H. H. Wilder (1899) for Desmognathus, the second for Autodax, by Ritter and Miller, also 1899, and the third by Montgomery for Plethodon in 1901. In all of these forms only the later stages were observed.

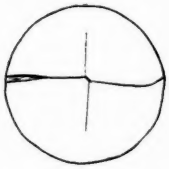


FIG. 1.—Surface view of a four-cell stage from above (about × 8).

As Desmognathus is very abundant in central New York, advantage was taken of the opportunity for a thorough investigation of the earlier stages.

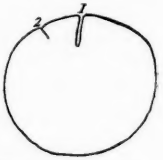


FIG. 2.— Section of four-cell stage, 1 and 2, first and second division planes (about × 8).

The eggs are about 3.5 mm. in diameter and entirely devoid of pigment. The general appearance is creamy white except at the animal pole, which is chalky white. In this chalky white area the first division furrows make their appearance. The first and second furrows are at right angles (Fig. 1), but soon these lose this geometrical regularity and the later division lines may be very irregular.

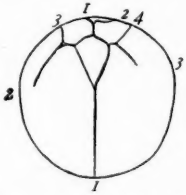


FIG. 3—Surface view of an eight-cell stage from the side, *1* and *2*, etc., first and second, etc., division planes (about × 8).

In the four-cell stage the first cleavage plane has cut somewhat deeper than the second, but neither has yet cut deeply into the central mass of yolk (Fig. 2). In the

[1] Due to a slight misunderstanding, both Dr. Wilder and the author have been working on precisely the same problem. Dr. Wilder's results, if not published by the time this appears, will be published soon. In his paper he comes to the conclusion that the eggs of Desmognathus are holoblastic and not meroblastic in cleavage. His conclusions were reached by the study of the surface views, and I am very glad of the opportunity to confirm his observations by the aid of a few sections of early stages as well as a few surface views. I will leave a more detailed account of the early development of this animal for a later paper.

next stage there is no distinct equatorial groove. The eight-cell stage is gradually derived from the four-cell condition by the appearance of furrows between the two original ones. In the eggs of this stage which Wilder has studied (see footnote) two rather regular vertical planes of cleavage cut the egg at nearly right angles to the first division plane, but in a considerable number of eggs which I have examined, some of them living and others preserved, I only found one or two with such regular vertical cleavage planes; in some there was an approach to it, but in a number of others the eight-cell condition seemed to be gradually derived from the four-cell stage by the appearance of furrows which were hard to recognize as parts of vertical planes of cleavage. In the eight-cell stage the first furrow nearly encircles the egg, but the position of the first and the second is often so shifted that it is difficult to believe that they were ever at right angles (Fig. 3). At this time the animal pole may be divided into one or more distinct blastomeres, but the vegetative pole shows almost no signs of cleavage planes (Fig. 4).

FIG. 4.—Section of an eight-cell stage (about × 8.)

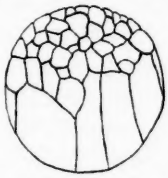


FIG. 5.—Surface views of a few-cell blastula from the side (about × 8).

As segmentation proceeds the surface appearances correspond in general with those of other amphibian ova (Fig. 5), but sections bring out the fact that the segmentation is shallow, and does not involve the whole thickness of the egg (Fig. 6). Later, however, when the surface appearance is like that of a fine celled blastula (Fig. 7), sections show that the segmentation has extended through the entire egg and that the cleavage in this stage is as truly holoblastic as in any other of the salamanders (Fig. 8).

FIG. 6.—Section of a few-cell blastula (about × 8).

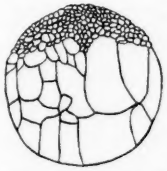


FIG. 7.—Surface view of a many-cell blastula from the side (about × 8.)

As the embryo increases in size the cell outlines in the yolk are lost, and if sectioned in this stage only, one would be justified in suspecting a meroblastic segmentation. This

idea is helped by the fact that the growing embryo soon comes to occupy a position on the yolk strikingly like that of a fish embryo.

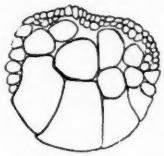


Fig. 8.—Section of a many-cell blastula (about ×8).

In a word, then, the segmentation of the ovum of Desmognathus is truly holoblastic, but the total cleavage is rather slow in appearing, and in the later stages of development the yolk mass becomes homogeneous by the disappearance of cell walls.

The Early Development of Dinophilus as Compared with that of the Annelids: James A. Nelson, University of Pennsylvania.—The ovum of Dinophilus segments into four cells, or macromeres, each of which gives rise by oblique alternating or "spiral" cleavages to five generations of smaller cells, or micromeres. The first three quartettes give rise to ectoderm. The posterior left hand member of the fourth quartette divides bilaterally and equally into two cells which later give rise to the mesoderm bands. The remaining cells give rise to the entoderm. This method of origin of the three germ layers is identical with that found in the Mollusca and the Polychæta. As in the two former groups the brain is formed from the first quartette, and the greater part of the trunk ectoderm from the posterior cell of the second quartette. In the details of the cleavage there is a striking agreement with that of the polychætous annelids. Cells arising from the first quartette identical in origin with the "primary trochoblasts" of the annelids, together with cells derived from the first and second quartettes, make up a cell row which very probably forms at least a part of the second ciliated band situated on the head of the adult, in a position corresponding with that of the prototroch of the annelid larva. Other details increase this resemblance. The symmetrical cell pattern known as "the cross" is formed by the same cells and at the same divisions as in the Polychæta, while in the divisions of the posterior cell of the second quartette bilateral symmetry appears at the same time and in the same cell as in several members of this group.

Such close agreement in the details of the cleavage, as well

as in the fate of the corresponding cells with the conditions obtaining among the Polychæta, speaks strongly for a genetic relationship between this group and the Dinophilidæ, since cleavage patterns are inheritable, as well as other characters.

Organ-forming Germ Regions in the Eggs of Ascidians and Snails: Edwin G. Conklin, University of Pennsylvania.— The early development of ascidians and snails is of such a determinate character, even in the earliest cleavage stages, that it seems probable that a definite polarity and localization of materials exists in the unsegmented egg. A study of the eggs of these animals shows that this antecedent probability is realized in fact.

In the living eggs of the fresh water snails, Limnæa, Physa and Planorbis, one may readily observe the segregation of unlike materials of the egg before cleavage begins. Before maturation the nucleus can be seen in such eggs as a large, clear vesicle, while the rest of the egg substance is filled with yolk granules and is yellow in color. During the maturation divisions the nuclear vesicle is dissolved and its contents form a clear area surrounding the polar amphiasters. After the second polar body is formed this clear area spreads out as a disk and then as a cap which covers the upper two-thirds of the egg. The lower third of the egg which is not covered by this cap of clear protoplasm remains of a bright yellow color. These two portions remain distinct throughout the subsequent development, the clear area giving rise to the ectoderm and the yellow one to the endoderm and mesoderm. In these snails, therefore, the germ layers are visibly outlined in the unsegmented egg.

A somewhat similar localization of germinal materials, before cleavage, occurs in the eggs of certain ascidians. In *Cynthia* (*Styela*) *partita*, *Ciona intestinalis* and *Molgula manhattensis* the central yolk mass of the immature egg is surrounded on all sides by a peripheral layer of protoplasm. In the living eggs of Cynthia the central yolk is gray in color while the peripheral layer contains granules of yellow pigment; in Ciona the yolk is red, the peripheral layer clear and transparent; in Molgula the yolk is gray, the peripheral layer clear. As soon as a sperma-

tozoon enters the egg this peripheral layer, together with the nuclear sap from the germinal vesicle, flows rapidly to the lower pole, at which point the sperm always enters. The yolk is left uncovered at the upper pole and here both polar bodies are formed. The protoplasm at the lower pole then moves up to a position just below the equator on the posterior side of the egg; and here the pronuclei meet and the first cleavage spindle arises. At the close of the first cleavage the greater part of the clear protoplasm moves into the upper hemisphere while the gray, yolk-laden protoplasm is largely collected in the lower hemisphere. In Cynthia the yellow pigment collects into a brilliant crescent, just below the equator on the posterior side of the egg; in Ciona and Molgula this crescent is clear and almost colorless. Owing to its color in Cynthia the substance of this crescent can be traced through the whole development until it gives rise to the muscle cells and the mesenchyme of the tadpole. The gray substance of the unsegmented egg gives rise chiefly to the endoderm, while the transparent protoplasm goes principally into the ectoderm. In these eggs, therefore, there is not only a localization of the material of the three germ layers before cleavage, but all the axes of the future animal are clearly established in the unsegmented egg.

An Experimental Examination of the Germ Regions of the Molluscan Egg: Edmund B. Wilson, Columbia University.—No abstract.

Polarity and Axial Heteromorphosis: T. H. Morgan, Bryn Mawr College.—The reversal of the polarity that is seen in axial heteromorphosis appears to give us an opportunity for an examination of the phenomenon of polarity itself, for, if we could determine the conditions that determine this reversal we might hope to gain some insight into the factors that determine the polarity. It is from this point of view that I offer the following observations on two species of planarians, *Planaria maculata* and *P. lugubris*.

If a planarian is cut in two at almost any level a new tail regenerates on the posterior end of the anterior piece and a new

head on the anterior end of the posterior piece. It appears that the same material is doubly potent, being able at nearly every level to form a head or a tail. Something in the piece itself determines that a head shall develop at the anterior cut surface and a tail at a posterior cut surface. This "something" is what we call polarity.

I have found certain exceptions in the planarians to this rule. Occasionally a cross-piece develops a head at each end, and in *Planaria lugubris*, especially, when the tip of the old head is cut off just behind the eyes, another reversed head regenerates from its posterior cut surface.

In the few cases in which I got double-headed forms I was impressed by the fact that this occurred only when the cross-pieces were very short, and never occurred in long cross-pieces. This lead me to try making the pieces very short in order to see if I could obtain in this way more of these double-headed forms. This I found to be the case, and I have obtained from such pieces double-headed forms from every part of the body of *Planaria maculata*. It is clear, therefore, that the result can not be connected with the presence of any particular structure at the cut end. A number of different kinds of experiments, mainly with pieces having obliquely cut ends, seemed to show that the main factor in the production of the heteromorphic head is connected with the shortness of the piece. I suggest as a tentative hypothesis that this shortening of the piece reduces the strength of the polarity so that it comes to have less influence on the new part than certain innate tendencies of the material itself. There is reason to conclude, as I have stated, that the new material that develops over the cut surface has the power of producing either a head or a tail. If now the polarity is reduced, or removed, that one of these two tendencies which is stronger will have a chance to assert itself. In the case of *Planaria maculata* the tendency to produce a head seems stronger than the tendency to produce a tail, hence the appearance of the heteromorphic head in the short cross-pieces, in which the polar influences fail to act. This conclusion I hold subject to future revision when we have gained more light as to the nature of the so-called polarity itself.

In *Planaria lugubris* I had found that when the head is cut off just behind the eyes a heteromorphic head is produced on the posterior end of the old head. From this result I confess that I anticipated that in this worm it would be even easier than in *P. maculata* to obtain double-headed forms from short cross-pieces. To my surprise I found on the contrary that these double-headed forms do not arise except in a few cases in which the cross-pieces have come from the region immediately behind the old head. Most of the other short cross-pieces produce a head and a tail, but in a small number of cases the structure that develops at the anterior end appears to be a tail. It would be difficult to determine with absolute certainty whether this anterior pointed structure is a heteromorphic tail or an undeveloped head, unless the pharynx were to develop. In one case a pharynx appeared in the new part at the anterior end, and another in the new part at the posterior end. In both the new pharynx pointed outwards, *i. e.*, towards the tip of the new part, hence there can be little question that the new structure is really a heteromorphic tail.

It appears in *Planaria lugubris* that while the material at every level has the double potency of producing a head or a tail according to which end of the piece it comes to lie at, yet in very short pieces from the middle and posterior regions of the body a double-tailed form may arise. We must suppose, therefore, on our hypothesis, that while in this species also the material is totipotent, yet when the determining influence of the polarity is removed the stronger tendency is to produce a tail, while in *Planaria maculata*, as we have seen, the stronger tendency is in the other direction.

In *Planaria lugubris* it has been necessary to assume that the most anterior part of the body has a different predisposition than has the rest of the body, since in the former a double-headed piece may develop and in the latter a double-tailed form. This result finds a parallel in certain other cases that I have observed in the earthworm and tadpole.

If an earthworm is cut in two behind the region of the gizzard there often develops from the anterior cut surface of the posterior piece of the worm a heteromorphic tail. In this case the

posterior part of the worm is not a short piece, and yet it is worthy of note that this region has practically the same structure throughout. This may mean that the conditions are fundamentally the same as those in the short cross-pieces of the planarian, and if so this may throw some light on the phenomenon of polarity itself.

It has also been shown in the earthworm by Hazen that from the posterior cut surface of a short piece of the head end a heteromorphic head may develop. Here we must assume that the tissues are predisposed to form a head, while in the posterior region they are predisposed to form a tail, and in both when the polar influences are removed these structures appear. It has been shown by Harrison in the tadpole that a tail-like outgrowth develops from the anterior cut surface of the tail. I have tried to show that this outgrowth is really a heteromorphic tail. Here again it is noticeable that the old tail has practically the same structure throughout, hence possibly, as in the earthworm, there may be a decrease in the polarity and the consequent development of a heteromorphic structure.

These considerations are tentative, and possibly premature: but the facts give us at least some grounds for the hope that the problem of polarity may not be beyond the reach of further analysis.

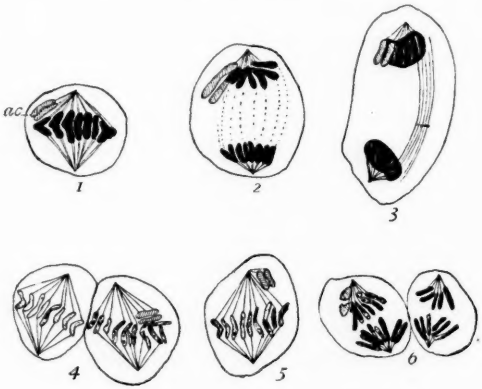
The Development of the Germ Layers in a Nudibranch Mollusc: Dana B. Casteel, University of Pennsylvania. — The cleavage of the egg of the nudibranch, *Fiona marina*, is of the spiral type well known for molluscs. From the mesentomere (4 d) arises the primary mesoblast and also enteroblasts, these latter being concerned in the formation of the intestine. Secondary mesoblast is formed from the third quartet of ectomeres in a manner similar to its formation in Physa and Planorbis. Two cells in each anterior quadrant sink below the surface into the cleavage cavity and by division there form two bands of cells on the sides of the anterior end of the gastrula. These elements later take part in the formation of the muscles of the velum, a larval organ, and are thus truly "larval" in character.

The anal excretory organ, characteristic of opisthobranch

larvæ, is undoubtedly of ectodermal origin in Fiona. It arises from one large and several small third quartet cells of the right posterior quadrant which, after torsion begins, are carried farther to the right side and above the anal opening. The larva also possesses additional organs of excretion, two in number, lying bilaterally in the anterior region of the body cavity. These, the "nephrocysts," are composed of but a few large vacuolated cells which contain concretions and fluid excreta. The origin of these cells has not been determined definitely, but they are probably derived from the mesoderm.

A Pair of Giant Nerve Cells of the Squid: Leonard W. Williams, Brown University. — No abstract.

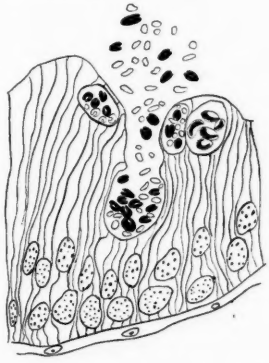
The Function of the Accessory Chromosome in the Spider: Louise B. Wallace, University of Pennsylvania.— In the spermatogenesis of insects a number of authors have described a



peculiar chromosome which has been called by various names. While these all agree in being unlike the ordinary chromosome, there seems to be sufficient disagreement to subdivide them into two groups. Montgomery's "chromatin nucleolus" and Paulmier's "small chromosome" are probably homologous and these authors have suggested that they may represent degenerating chromatin. McClung's "accessory chromosome" in Orthoptera

is too well developed to allow of such an explanation and since it divides in the second maturation division only and is thus distributed to but one-half of the spermatids, he regards it as a sex-determinant.

In the spider *Agalena nævia*, the peculiar chromosome closely resembles the one described by McClung and therefore I adopt his term but my results differ from his in regard to its distribution. I am convinced that, although split longitudinally, it takes part in neither of the maturation divisions and that, therefore, only one-*fourth* of the resulting spermatids possesses it. Such a condition would hardly favor the idea of sex-determination. Figures 1, 2 and 3 show spermatocytes of the first maturation division and Figures 4, 5 and 6, spermatocytes of the second maturation division.



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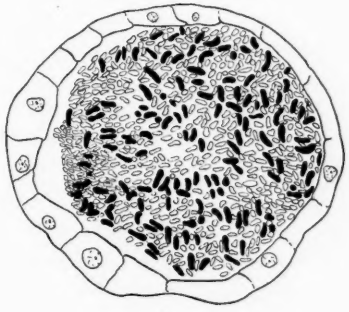

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In nests of maturing spermatozoa are found cells undergoing degeneration (Fig. 7) and these occur in great numbers in the testis and also in the ducts (Fig. 8) together with the much smaller number of ripe spermatozoa. This fact leads me to suggest that possibly only those spermatids which contain the accessory chromosome develop into functional spermatozoa and that the remaining three-fourths never reach maturity. If this interpretation be a true one, a parallelism could be drawn between the development of the spermatozoön and of the ovum, since in the latter only one of the four oötids develops into a ripe ovum,

the other three being thrown off as polar bodies and later degenerating.

The Lamellibranch Nervous System: Gilman A. Drew, University of Maine.— The nervous system of the giant scallop, *Pecten tenuicostatus*, is greatly specialized, and the size of the animal makes it possible to study it by dissection as well as by serial sections. The cerebral and pedal ganglia are small, owing no doubt to the reduction of the parts they supply, and the visceral ganglia, supplying the large adductor muscle and sending a large number of nerves to the borders of the mantle, are very large and composed of distinctly marked regions. The pallial nerves that follow along the borders of the mantle lobes near the bases of the tentacles and eyes, present the structure of ganglia and supply nerves to the tentacles and eyes, which are very abundant in this form. The need for such ganglia is apparent, and their presence instead of a further complication of the visceral or cerebral ganglia indicates the ease with which such centers may be established when need arises.

The fact that the pallial nerves, that here show the structure of ganglia, are joined at intervals for nearly their whole length by nerves from the visceral ganglia, while only a very few nerves are sent to them from the cerebral ganglia, and these only to their extreme anterior ends, is taken as an indication that the loss during development of the anterior adductor muscle is accompanied by a suspension in the growth of other anterior portions, and that the bulk of the animal if formed by the excessive growth of the posterior portions.

The relation of the nervous systems of other lamellibranchs was also discussed.

The Early Stages in the Development of Ophiothrix Fragilis: E. W. MacBride, McGill University.— Comparatively few and scattered notices are to be found in zoölogical literature with reference to the early development of Ophiuridea and in a preliminary notice like the present communication, it will only be necessary to refer to one of them. In 1891 Russo[1] published

[1] Le prime fasi di sviluppo nell' Amphiura squamata — *Bollettino della Società in Naturaliste* in Napoli. Vol. 5, 1891.

an account of the formation of the layers in the embryo of the viviparous *Amphiura squamata*; and in that paper he made the startling statement that in *Amphiura squamata* the endoderm was formed by delamination from the inner ends of cells forming the wall of a hollow blastula, and that, further, the cœlomic sacs appeared as cleavage spaces in the midst of masses of mesenchyme cells.

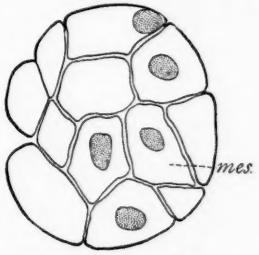

FIG. 1.—Section through the segmenting egg *mes.*, internal cells separated by tangential division.

Such fundamental differences between the developmental processes in this form and those in all other Echinodermata, were hardly to be credited without ample confirmation, especially when it is recollected that Amphiura squamata is not a favorable object for study owing to the difficulty of obtaining the earlier stages in quantity.

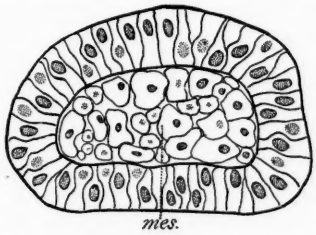

FIG. 2.— Section through embryo at the close of segmentation.

For this reason I selected the common British form, *Ophiothrix ragilis* for study, and, during a visit to the Plymouth Biological Station in 1898 I artificially fertilized a number of the eggs and reared some of the larvæ through the entire period of development up to and including the metamorphoses, the whole occupying about three weeks.

The egg of *Ophiothrix fragilis* is very minute, being less than .1 mm. in diameter, and is quite opaque so that in order to follow the earlier stages of development it is necessary to use serial sections.

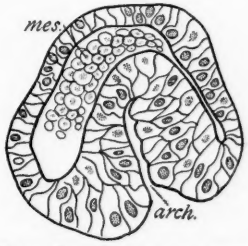

FIG. 3.—Longitudinal section of young gastrula *arch.*, archenteron.

As shown in Figure 1, the result of segmentation is not as in other Echinodermata, a hollow blastula, but a solid morula. From a comparison with one

another of my preparations, it appears that the egg at first divides into a few blastomeres, which are arranged around a vestigial, or perhaps we might say virtual blastocœle, and that as development proceeds this blastocœle swells but is kept continually filled by cells produced by tangential divisions of the peripheral blastomeres. At the conclusion of segmentation, the embryo strikingly recells a cœlenterate planula, as shown in Figure 2.

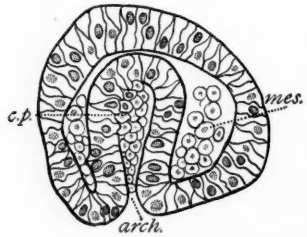

FIG. 4.—Longitudinal section of older gastrula *arch.*, archenteron *c p*, cellular plug.

The interior mass of rounded cells, however, does not constitute the endoderm, for, in the next stage (Fig. 3) a regular invagination has made its appearance, giving rise to an archenteron, which is, however, two or three cells thick on one side. The interior cells of the former stage are seen to occupy the space between archenteron and ectoderm, homologous with the segmentation cavity of other forms. In the completed gastrula

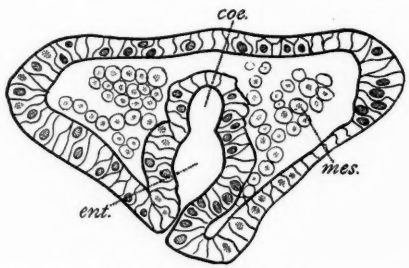

FIG. 5.— Longitudinal section through an embryo two days old *cœ.*, cœlom *ent.*, enteron.

a curious plug of cells is seen projecting into the archenteron which is no doubt the remains of the thickened side of the archenteron of the younger gastrula (Fig. 4).

When the embryo has attained the age of two days, the rudiment of the cœlom appears as a vesicle at the anterior end of the archenteron exactly as it does in the embryos of Asteroidea. At the same time the embryo takes on a shape which may be

described as roughly triangular. The two basal angles of a triangle (Fig. 5) are really the rudiments of the first two arms of the larva, which throughout the whole larval existence are much longer than the rest, and are the most important organs of locomotion. The cells which form the interior mass at the close of segmentation are now seen to be destined to form the supporting calcareous rods for these arms, and hence we may attribute the leading peculiarity of the development, *viz.*: the appearance of a solid morula instead of a hollow blastula, to the extremely precocious formation of the skeletogenous cells for these arms.

On the Homologies of the Archenteron and Blastopore in Vertebrates: Charles S. Minot, Harvard University.— No abstract.

Medusa Fauna of the Bahamas: Alfred Goldsborough Mayer, Brooklyn Institute of Arts and Sciences.— The medusa fauna of the Bahamas is poor in comparison with that of the Tortugas, Florida. The writer secured ninety (90) species of Hydromedusæ, Scyphomedusæ, Siphonophoræ and Ctenophoræ at the Tortugas, while only forty-three (43) species were found at the Bahamas. What is more interesting, the relative abundance of specific forms is quite different in the two regions. The commonest medusa during the summer months at the Tortugas, *Pseudoclytia pentata*, is not found at the Bahamas, and the commonest medusa during the summer months at the Bahamas, *Lymnorea alexandri*, is not found at the Tortugas.

Altogether, of the forty-three species of Bahama medusæ, twenty-three (23) are about equally abundant on the other side of the Gulf Stream at the Tortugas. Sixteen are more abundant at the Bahamas than at the Tortugas, while four are more abundant at the Tortugas. This is accounted for by the following facts: The Tortugas lie to leeward of the Gulf Stream and the extraordinarily rich pelagic life of the great current is constantly driven upon their shores, while the Bahamas lie to the windward of the stream and their local fauna is not reinforced by creatures characteristic of the great current. There is, however, something more than a mere concentration of individ-

uals at the Tortugas, for a surprising number of characteristic species appear to be confined to this region alone. Moreover, at the Tortugas, we have a small land mass surrounded by pure deep ocean water, while at the Bahamas we find a vast area of shallow flats covered mainly by coralline mud, forming veritable submarine deserts covered only with a sparce growth of coralline algæ and a few scattered clusters of coral reefs and gorgonians. The water over these shallow banks is almost as deficient in life as is that of the desert bottom itself, very few Sagittæ, Salpæ or Crustacea being found, and among the Medusæ only representatives of the Gonionemidæ and Lymnorea are abundant. Indeed, the water of these shallow banks is usually charged with a flocculent mass of silt which adheres to pelagic animals, and appears to be rapidly fatal to them. The deep water regions of the Bahamas, however, such as the tongue of the ocean, or the water to the eastward of Great Abaco Island, are rich in pelagic animals which appear to be free from silt and in good condition. This water of the deep areas must, however, be often driven over the shallow banks by the winds, and its life be thus destroyed.

It is found that Olindias is closely related to Gonionemus, for in its ontogeny it passes through a stage in which all of the tentacles arise from the side of the bell, and are sucker-bearing as in Gonionemus. *Eucheilota paradoxica* is the only Leptomedusa known which produces an asexual generation of Medusæ by a direct process of budding. These daughter Medusæ are derived from both ectoderm and entoderm of the gonad of the parent, as is the case in the Sarsiadæ and in Hydroids. On the other hand, the Medusæ buds found upon the manubrium of *Bougainvillia niobe* are developed entirely within the ectoderm, the entoderm remaining inert and passive during the growth of the bud, its limiting membrane being unbroken, and no connection ever being established between the gastro-vascular cavities of the bud and the parent. In *B. niobe*, however, the ectoderm of the manubrium is of considerable thickness, affording abundant material for the formation of the bud. It is possible, therefore, that this peculiar method of formation of medusa buds from the ectoderm, which has been observed in *B. niobe* by

us, and in *Rathkea octopuncta* and *Lizzia clappadei* by Chun, may be due to a gradual process favored by the thickness of the ectoderm which may have prevented the deep-lying entoderm from taking an equal share in the formation of the bud until finally it has come to remain passive throughout the period of formation of the bud, as in *B. niobe*.

Medusæ produced from ectoderm alone may, therefore, be phylogenitally homologous with Medusæ produced by the more primitive and universal coöperation of both ectoderm and entoderm.

Among the new forms discovered, *Parvanemus degeneratus* is the most degenerate free-swimming hydroid medusa yet described. It lacks tentacles, sense organs and peripheral vascular system. It swims, however, with great activity, but is short lived.

Correlation as the Basis for Selection in Lepidoptera: Henry E. Crampton, Columbia University.— Read by title.

Exhibition of a Cat, Showing Abnormal Placement of Viscera: C. M. Clapp, Mount Holyoke College.— No abstract.

The Origin and Function of the Medullary Sheaths of Nerve Fibres: Porter E. Sargent, Browne and Nichols School, Cambridge.— No abstract.

Demonstration of Pulsatile Anterior Lymph Hearts in Young Tadpoles: Henry McE. Knower, Johns Hopkins University.— No abstract.

Excretory Activities in the Nuclei of Gastropod Embryos:[1] O. C. Glaser, Johns Hopkins University.— The primitive urinary bodies of the larva of *Fasciolaria tulipa* attain great size and are very favorable objects for study. They originate as two pear-shaped patches of highly vacuolated ectoderm at the sides of the definitive mouth. On account of their connection with

[1] The material on which this work was done was collected during three summers in North Carolina. I am deeply indebted to the Hon. Geo. M. Bowers for the courtesies of the Beaufort Laboratory of the Bureau of Fisheries.

the velar fold they are later carried outwards from the wall of the embryo and ultimately hang down from the under side of the velum.

Between the two extremes in development mentioned, the cells composing these bodies increase in size, in number by addition, and undergo a period of active excretion. Early in this period the nuclei divide amitotically, and the cells become polynucleated. The nuclei are granular, very irregular in outline, and each one has at least one nucleolus surrounded by a clear area. In addition the cells are characterized by their highly vacuolated condition (Fig. 1).

In sections through these nuclei, before and after amitosis,

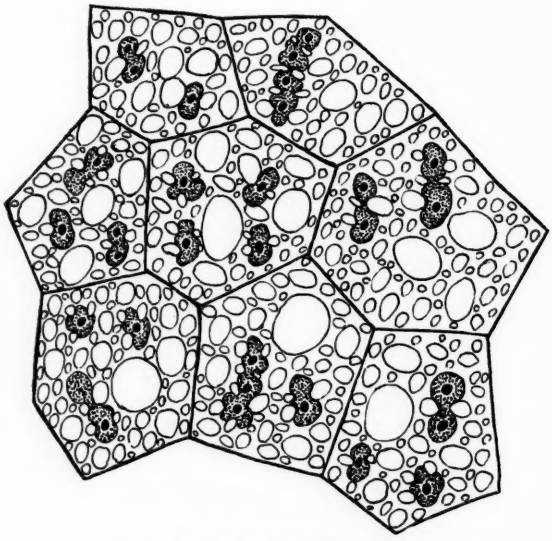

FIG. 1 — Surface view of part of external kidney.

the chromatin is arranged in an irregular network (Fig. 2 A, B, C). The nucleolus (*nl*) has a different staining reaction, and is probably a typical plasmosome. The halo surrounding it, instead of being circular or oval in outline, as it appears to be in whole mounts and in optical sections, is highly irregular, its outline projecting in finely attenuated processes into the body of

the nucleus. These processes are so delicate and the granules bounding them so small in comparison with the chromatin granules in the network, that they are invisible except in sections. The location of large chromatin granules continuous with the nuclear reticulum, in the indentations of the halo, explains its circular appearance in entire preparations, because these granules are the only parts of the outline visible. They also afford an explanation of the irregular outline itself, for if we imagine a sphere of liquid to proceed out from the nucleolus in all direc-

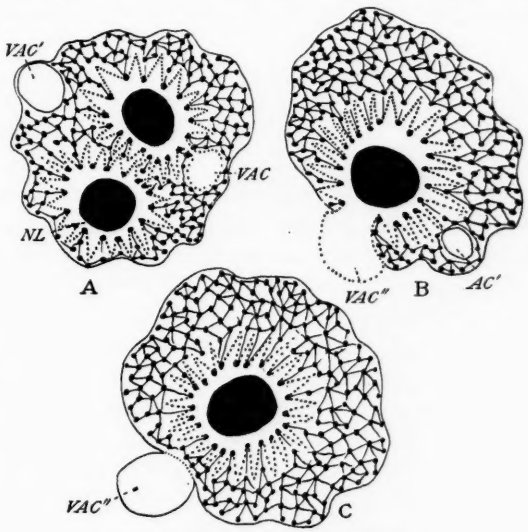

FIG. 2.— Sections of nuclei of excretory cells.

tions, any larger objects with which it might come in contact would, after yielding as much as possible, detain the surface at certain points, allowing it to advance only where there is no resistance, *viz.*, between the larger granules. In many cases the projections of the halo end distally in bulges or vacuoles (A, *vac*) which, apparently through the agency of the larger granules of the nuclear reticulum, become constricted off and may afterwards be found loose in the nucleus (A, B, *vac'*), from which they may finally escape (C, *vac''*). In other cases the projections of the halo may break through the wall of the nucleus before the vacuoles separate (B, *vac''*).

These phenomena strongly suggest an excretory activity, and this suggestion is strengthened by our knowledge of the behavior of amitotically dividing nuclei in other animals, but especially by the results of R. W. Hoffmann on the behavior of the nuclei and nucleoli in the large macromeres of the embryos of Nassa mutabilis. Complete proof, however, that the activities described in the sub-velar masses of Fasciolaria are really the exhibition of an excretory process, is found in a chemical analysis of an aqueous extract of these bodies. Such an extract analyzes like a dilute solution of urea.

Double Reproduction in the Medusa Hybocodon prolifer: H. F. Perkins, University of Vermont.— Hybocodon is familiar to American biologists as a singularly asymmetrical jelly-fish found along our coast in the early spring. Of the four radial canals only one is continued beyond the bell in a tentacle.

The method by which this medusa has been described as reproducing its kind is by developing, upon the bulbous base of this solitary tentacle, gemmiferous buds. These, when mature, become detached from the parent and swim away as free jelly-fish. Only the one tentacle is developed upon these buds, and at the time of liberation the base of this tentacle frequently carries maturing buds of a second generation.

While this is a rapid and efficient means of propagation, it is not the only one. In addition to this asexual process, a sexual process is also present. Eggs or sperms are produced within the gonads which surround the manubrium, and these develop within the tissue to the condition of tentacled actinula larvæ. Thus the adult Medusæ give origin to two sorts of offspring, one by gemmation, the other by sexual production of viviparous young. This in itself is not anything extraordinary, but it is a matter of interest that the two processes are found taking place simultaneously in the same individual, and that this coincidence does not lessen the rapidity with which the embryo jelly-fish are produced on the tentacle bulb. The fact is of interest only as showing that the reproductive activities of Medusæ are even more unrestricted than we have realized.

The sexually produced larvæ of Hybocodon mature upon the

wall of the parent manubrium, attached to this member, after the earliest stages, by a slender connecting stalk. Ten tentacles appear while the larva is still a spherical mass, and as they lengthen assume a direction pointing away from the point of attachment. The mouth and oral tentacles of the actinula are developed after liberation at the pole which was, during the attached period, next to the parent.

The Development of the Heart and Branchial Blood Vessels of Ceratodus: William E. Kellicott, Columbia University.— No abstract.

Regeneration in Scyphomedusæ: Chas. W. Hargitt, Syracuse University.— Notwithstanding the remarkable development and scope of experimental zoölogy during the past decade, extending to members of every phylum from Protozoa to Vertebrata, comparatively little has been done directly upon any of the Medusæ, and almost nothing upon Scyphomedusæ. The incidental reference of Haeckel to such a tendency among certain of these organisms is hardly more than a hint, with nothing whatsoever as to details. Such is also the case with the later work of Eimer and Romanes on the nervous system of the Medusæ, at least as it pertains to problems of regeneration, though painstaking and important in its bearings on problems of locomotion and co-ordinated activities. More recently Uexküll has also reviewed some of this work, and while differing in many respects from that of his predecessors as to conclusions, leaves untouched the subject of regeneration.

The series of experiments of which this abstract furnishes the barest outline was undertaken with a view to ascertain the comparative capacity of Scyphomedusæ to reproduce lost parts, such as bits of the various parts of the body which might be lost by the usual exigencies of the struggle of life. The experiments comprised some three phases of regenerative energy:— First, the general ability to recover from such injuries as rents of the umbrella, etc.; second, regeneration of such organs as oral appendages; third, ability to regenerate such specialized organs as the sensory bodies.

Concerning the first, it required but few experiments to determine very clearly the existence of such a capacity, though its progress was somewhat more slow than had been anticipated. Various rents of the umbrella were soon healed, but excisions of the margins of the body were regenerated much more slowly.

Concerning the second class, the responses were similarly slow. An excised oral arm required several weeks to completely regenerate, as was also the case with excised portions of the gastric pouches.

Concerning the third class I had entertained some doubt, namely the power to reproduce the more specialized organs, such as rhopalia or sensory bodies. The experiments were an agreeable disappointment, as these organs were quite as promptly regenerated, if not indeed more so than had been the case with the former. In some cases the first signs of regeneration were noted within five days of their excision, and in from eight to twelve days their functional power was clearly recovered, as was proved by details of experimentation impracticable to describe here. The associated organs, such as lappets, hood, etc., were also quite as fully regenerated as the other.

Histological examinations show beyond any doubt the operation of typical histogenic processes, various phases of the regenerating organ being easily traceable from stage to stage to perfect maturity of form and structure.

In earlier experiments of a similar sort made upon Cyanea and Aurelia by the writer it was found impossible to maintain the normal vitality of the animals for sufficient time to secure any conclusive results. Rhizostoma, however, lends itself most remarkably to experimentation of various sorts and for continuous periods of from four to six weeks without material loss of vigor or regenerative power. It was found, however, that this was somewhat dependent upon the size and, presumably, age of the specimens. Those of large size, 75 to 125 mm. in diameter, proving much less hardy under an aquarium environment than specimens of smaller size; though very small specimens also proved less satisfactory. Specimens of from 40 to 60 mm. in diameter proved much the better, not only from the apparently greater vigor, but also in convenience for experimentation and observation.

The experiments clearly prove the capacity among these organisms for regeneration of organs or parts of organs, from the more generalized sort to the most specialized, and that with approximately similar readiness.

A New Generic Type of Polygordidæ: J. Percy Moore, University of Pennsylvania.— The annelid referred to is known only from a couple of fragmented specimens found in association with marine Oligochæta on Cape Cod. Like Polygordius it has a slender, elongated form, an acutely conical prostomium bearing a pair of prominent, slightly articulated, apical tentacles, a round, open mouth, and above it a pair of deep, ciliated, sensory pits. The segments are very obscurely indicated externally in the anterior region but are clearly defined at the caudal end. The body wall exhibits the same succession of layers as in Polygordius; and internally are found a similar digestive tract with eversible proboscis, divided of the cœlom by transverse intersegmental dissepiments and dorsal and ventral longitudinal mesenteries, an oblique muscle band supporting the metameric gonads, and an epidermal nervous system ending anteriorly in a bilobed cephalic ganglion. In all these and other characters the worm resembles Polygordius, but in three important respects differs from that genus.

By an arrangement which can be described as a shortening of the oblique muscle sheet, the thick layer of longitudinal muscles is folded on each side in the form of a longitudinal ventrolateral ridge in which the muscle fibres assume (in transverse section) a radial arrangement and undergo certain structural changes. Thus is approached the condition found in many of the more primitive Polychæta and the manner in which the segregation of the dorsal and ventral longitudinal muscle tracts of annelids may have occurred is indicated.

At the caudal end the last ten or twelve somites are setigerous. Two of these bear a pair of seta on each side but the others only a single slender, vitreous, capillary seta, which arises on each side from the place of insertion of the oblique muscle and curves over the back for a distance nearly equalling the diameter of this region.

The anal segment or pygidium shows no enlargement nor other peculiarities exhibited by most species of Polygordius. There are no marginal papillæ or special appendages of any sort, but the pygidium continues the general outline of the rest of the caudal region to the anus. The caudal setæ evidently serve the same purpose as the bulbous enlargement with its papillæ of Polygordius in anchoring the posterior end of the worm. For this worm the name of *Chætogordius canaliculatus* is proposed. Its chief interest is that it somewhat bridges the gap between Polygordius and the Polychæta and partially confirms the view expressed thirty years ago by McIntosh that Polygordius finds its nearest polychæte relations in the Opheliidæ.

The First Steps Toward Degeneration in the Parasitic Copepods: Charles B. Wilson, State Normal, Westfield, Mass.— No abstract.

Gymnandromorphous Ants; W. M. Wheeler, American Museum of Natural History.— No abstract.

Trematode Parasites of American Frogs: H. S. Pratt, Haverford College.— Up to the present time the following species of trematodes have been found in American frogs:— *Halipegus* (*Distomum*) *ovocaudatus* Vulpian in the mouth and eustachian recesses; *Hæmatoloechus* (*Distomum*) *longiflexus* Staf., *H. similiplexus* Staf., *H. breviplexus* Staf., *H. varioplexus* Staf., and *Ostiolum* (*Distomum*) *formosum* Pratt in the lungs; *Pleurogenes* (*Distomum arcanus* Nickerson encapsuled in the pylorus and the liver; *Distomum quietum* Staf. *Cephalogonimus americanus* Staf., D. retusum Leidy, and Holostomum nitidum Leidy, in the small intestine: *Diplodiscus* (*Amphistomum*) *subclavatus* Gœze in the rectum; *Gorgodera* (*Distomum*) *amplicava* Looss, *G. simplex* Looss, *G. attenuata* Staf., and *G. translucida* Staf., in the urinary bladder; *Distomum tetracystis* Gal. encapsuled in the muscles of the throat; and *Monostomum ornatum* Leidy in the body-cavity.

The Structure and Development of the Compound Eye of the

Bee: E. F. Phillips, University of Pennsylvania.— The ommatidia which make up the compound eye of the honey bee are each composed of a crystalline cone of four cells and a rhabdome surrounded by eight or occasionally nine retinular cells. Each ommatidium is sheathed by two kinds of pigment cells, the inner pigment cells, two in number which surround the base of the crystalline cone and the outer pigment cells, twelve in number which extend the entire length of the ommatidium. Each retinula cell sends in a process to the retinular ganglion which has the property of a nerve fibre. The nerve fibres of the eye are differentiated portions of the retinular cells which send in fine branches to the rhabdome, which is probably the nerve ending of the eye. There is no connection between the crystalline cone and the rhabdome and the cone has not a sensory function.

The ommatidia develop from a single layer of thickened hypodermis and the region of the compound eye is marked out in the unhatched larva. The first indication of ommatidia is the grouping of cells with a distinct boundary in young larvæ. The cells of these groups become differentiated until each group is composed of a spindle-shaped mass with large nuclei, surrounded by numerous cells with smaller nuclei. The central spindle forms the retinula and the rhabdome is early visible as a clear space at the outer surface. The crystalline cone arises from the sides of the retinula and the pigment cells are still farther out. The ommatidium is formed as a morphological invagination of the hypodermis as was held by Watase. The rhabdome and crystalline cone are formed as intracellular secretions and the lens is secreted by the inner pigment cells whose nuclei in the young pupal eye are distal to the cone and afterward migrate to the base of the cone.

THE ANATOMY OF THE CONIFERALES.

(*Continued from page 359*).

D. P. PENHALLOW.

Resinous Tracheids and Resin Cells.

The investigations of Eichler (11, p. 35) show that in Ginkgo the wood is characterized by the presence of wood parenchyma elements which take the form of short idioblasts of a lenticular form in longitudinal section, and are distinguished by the storage of crystals of calcium oxalate. These structures are peculiar to this genus in which they form a specific character of definite value, but a more detailed account of them at this time is not called for.

In a large proportion of the Coniferales the wood is characterized by the presence of more or less numerous wood-parenchyma cells. These are always distinguished by their cylindrical form and transverse terminations. They are invariably associated with the production of resin, either as entering into the composition of resin passages, or as isolated cells. It is this latter group with which we are most particularly concerned at the present moment and as, with very few exceptions, they are uniformly characterized by the presence of resin which gives them a distinctive appearance, I prefer to describe them as "resin cells" rather than by the more commonly employed designation of "wood-parenchyma," which conveys no suggestion of their special function and most prominent feature.

Before proceeding to consider these structures more in detail, it will be necessary to digress for a short time and discuss certain other elements which have been erroneously regarded as wood-parenchyma. It has been stated by Eichler (11, p. 35) that wood-parenchyma elements occur in Araucaria and Agathis, but this is evidently due to a wrong interpretation of certain features presented by species of those two genera, which, according to

our investigations, are wholly devoid of such structures, in the sense defined above.

In *Araucaria excelsa* a transverse section shows more or less numerous elements containing resin. These are not to be distinguished in their general structure from the surrounding tracheids, and they are to be recognized solely by their contents, which are usually somewhat prominent. Their distribution is characteristic. They occur in small, scattered groups, or more commonly in rows one or two elements wide, parallel with the medullary rays and in immediate contact with them on each side. When the plane of section passes near the position of the supposed terminal walls the latter may be seen to be cut through in various ways, but they never exhibit any structural features, and they are therefore in no way comparable with the terminal walls of the wood-parenchyma cells. In a radial section they are seen to be long and fusiform, exactly resembling the wood tracheids, except for a reddish brown transverse plate which occurs either close to or exactly opposite a medullary ray, a position which is more clearly shown in a tangential section (Fig. 35). The dark plates closely resemble Sanio's bands, for which they might very readily be mistaken upon casual observation, or they might likewise be mistaken for terminal and unpitted walls. In *Agathis australis* these features are represented in their typical form. The transverse section shows such elements to be numerous and disposed in radial rows on each side of the medullary ray (Fig. 32). In a radial section they present the same fibrous and fusiform character as in Araucaria, but in addition the wall usually experiences a marked increase in secondary growth within a region exactly opposite the ray (Fig.

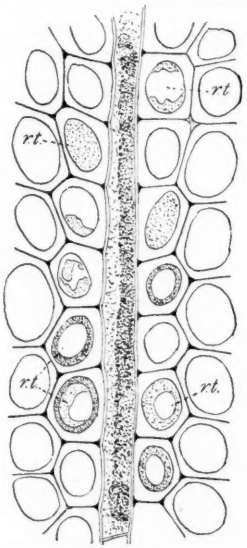

FIG. 32.—*Agathis australis.* Transverse section showing the disposition of the resinous tracheids on opposite sides of the medullary ray at *r. t.* × 300.

33). This feature is also prominent in a transverse section (Fig. 32). Such local increase in thickness always arises in adjacent cells in such a way that the more strongly thickened regions are exactly opposite, and they serve to constrict the cell cavity gradually from above and below in such a way as to leave a channel about half the usual width of the cell cavity, which gradually widens upward and downward (Fig. 33). It is at the position of maximum constriction that we find a transverse plate of variable thickness, but always of a reddish brown color. These plates are always thinnest in their central region, and they may be of uniform thickness for the greater part of their extent. At the region of contact with the tracheid wall they become thicker and thereby attain a vertical distribution to an extent four or five times greater than the general thickness. At such position also there is somewhat clear differentiation between the plate and the wall in point of color. Such plates show absolutely nothing of the nature of pits, and they are in no sense comparable with the terminal walls of the wood-parenchyma cells, except in form and position (Fig. 33).

The peculiar position of these plates, their resinous color and their simulation of both Sanio's bands and terminal walls, excited a suspicion as to their true nature and led to the belief that they might not be structural features at all. They were therefore subjected to a series of careful tests to determine (1) if they were structural, (2) if they were resinous, and (3) if the latter, to what extent. It was recalled in this connection that, although devoid of any special secretory reservoirs in the wood, Agathis is nevertheless well known for its production of the resin called gum dammar. It was suspected that the plates might be local deposits of resin, and they were therefore brought into direct comparison with gum dammar,

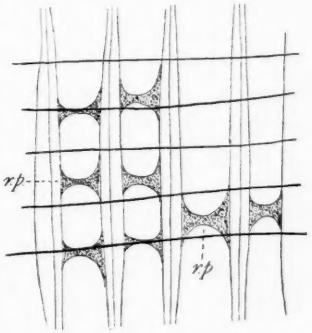

FIG. 33.—*Agathis australis*. Radial section showing the local thickening of the tracheid wall, and the occurrence of resin plates (*r. p*) opposite a medullary ray. × 225.

the characteristics of which are well known and described by Wittstein (D. 53, p. 63). Tests were applied to thin radial and tangential sections, employing for this purpose (1) various essential and fixed oils, (2) ether, (3) alcohol, (4) ammonia, (5) potassium hydrate in one and one half percentage solution. The plates were found to be very refractory with respect to both the fixed and essential oils, as well as towards ether, alcohol, ammonia and xylol, and in all of these cases no change was to be observed, even after an action extending over several weeks. A partial exception applies to alcohol and ether. In the latter case there did appear to be a certain diminution in volume, apparently through solution, when the reagent was first applied, but after that there was no further alteration. The application of alcohol, both in the hot and in the cold, showed that while the resin contained in the medullary rays was all dissolved, the plates were only partially affected. The reaction of the reagent was chiefly manifested in the development of strong curvature, often accompanied by fracture. This was evidently due to an increase in volume, and a tendency toward solution, and it gave the first definite evidence that the plates could not be of a cellulose character. Beyond this no further change was brought about, even after several weeks of action. The potassium hydrate gave the most positive results. At first there was no apparent change, but after an interval of about ten days or two weeks the plates were found to have completely disappeared, leaving a perfectly clear channel in the cell cavity. A further proof of the resinous character of these plates is to be found in

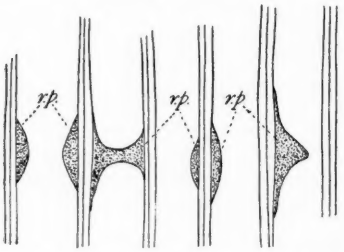

FIG. 34.— *Agathis australis*. Radial section showing the origin of the resin plates (*r. p.*). × 225.

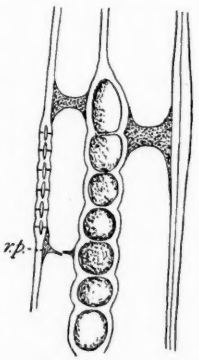

FIG. 35. — *Agathis australis*, Tangential section showing the relation of the resin plates and the medullary ray, and a fractured plate (*r. p.*). × 225.

the ruptures which they not infrequently exhibit (Fig. 35), and in the various developmental stages which may be seen not infrequently (Fig. 34). These show that resin gathers locally upon the inner face of the tracheid wall, and as its volume increases it projects toward the center from all sides, until complete coalescence occurs.

The facts thus obtained proved most conclusively that the transverse plates are obviously resinous and not of the nature of cellulose, even partially, and the conclusion appeared to be justified that they consist of gum dammar, but of a highly modified and highly refractory character. The same evidence also conclusively shows that the cells in which the plates are developed are normal wood tracheids and not wood parenchyma, which is altogether unknown in both Araucaria and Agathis, within the limits of the investigated species.

We are naturally led to ask what is the purpose of these resin plates? The peculiar form in which the resin is deposited, and the particular location of the plates, points with much force to their connection with some functional activity, since if it were simply a question of storage of the secreted products the latter would hardly be disposed as found but rather after the manner common to so many of the Cupressineæ; and this suggestion gains strength from the fact that both in the particular form of the resin masses and their location in the tissue, Araucaria and Agathis are peculiar among all allied genera. No exact comparison can be established with other plants, and it is difficult to suggest an explanation which is adequate. One thing does seem clear, however, and that is that since these plates are of an impervious nature and developed, in some cases at least, in connection with a special constriction of the tracheid cavity, they offer, and possibly they are specially designed to afford, a definite obstruction to circulation in a vertical direction. In this sense they may be designed to serve the same general purpose that is accomplished by the development of thyloses in the vessels of the angiosperms, or in the resin canals of the higher Coniferæ. It is therefore possible that they may be connected in some way not at present clear, with a more complete restriction of the circulation to a radial direction, and

particularly through the medium of the medullary rays as specialized channels for that purpose.

The occurrence of such resinous tracheids is almost exclusively confined to Araucaria and Agathis, in which it is a feature of particular species, but it is a noteworthy fact that similar structures occur, though rarely, among the higher Coniferæ. In the genus Abies they are prominent features in both *A. fraseri* and *A. grandis*. In the former a transverse section shows them to be prominent and scattering through the summer wood, more rarely in the spring wood, while in the radial section the resin is seen to be massive in the summer wood, forming a peripheral layer in the spring wood. In *A. grandis* the resin is usually more abundant, but otherwise the features are the same.

The taxonomic value of the resin tracheids applies exclusively to Agathis and Araucaria, where they are of specific value, and permits of the differentiation of at least one species in each genus. In Abies such tracheids are so sporadic and present so little constancy as to be of no great value.

Returning to a consideration of the resin cells, these structures are found to be entirely wanting in those species of Taxus (4) and Torreya (3) which are included in the present studies. They do occur, however, in Podocarpus where they present the usual structural features, but they are there remarkable for their number and the great abundance of massive resin which they contain. This distribution in the Taxaceæ does not altogether accord with the conclusions of Eichler (11, p. 35) who states that they occur very sparingly in Taxus, but he makes no mention whatever of their presence in Podocarpus where they are much too prominent to escape even the most casual observation.

In the Coniferæ, resin cells are characteristic of all genera except Picea and Pinus, where they are completely replaced by resin passages. They are therefore features in the wood structure of twelve genera, and they are constant characteristics of all their species, with very few exceptions. Such exceptions apply exclusively to the genus Abies, in which four species — *A. fraseri*, *A. lasiocarpa*, *A. veitchi*, and *A. balsamea* — are wholly devoid of such structures.

The recognition of the resin cells presents no difficulty in the great majority of cases because of the abundance and depth of color of the resinous contents. This finds its most complete expression in Taxodium, Sequoia, Cupressus, etc. In Abies, on the other hand, where these cells have experienced extreme numerical reduction and where there also seems to be a corresponding reduction in their secretory power, it is impossible to recognize them in this way. In such cases it is often possible to distinguish them by their slightly different form and somewhat thinner walls as compared with the adjacent wood tracheids; by their situation slightly in advance of the outermost row of summer wood tracheids; and most particularly by their pitted terminal walls when the latter lie near the plane of section. This last feature may also be relied upon in all other cases when any element of doubt is involved (Fig. 36). In longitudinal section the characteristic form of the cell serves to distinguish

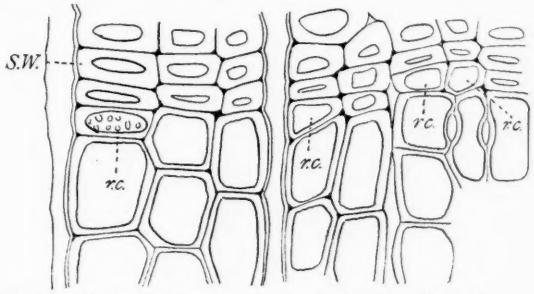

FIG. 36.— *Abies amabilis.* Transverse section showing the positions and structure of the resin cells (*r. c.*) on the outer face of the summer wood (*S. W.*). × 300.

it beyond all doubt, even in the absence of resinous contents. Whether exposed in radial or tangential section, the cell has the form of a narrow cylinder upwards of 300 μ in length, and always several times longer than broad, except in cases where there is a definite tendency, through aggregation, to the formation of resin canals.

The resin cells sometimes occur in pairs, but more generally as isolated structures separated by one or more tracheids. The terminal walls are transverse and more or less strongly marked with simple pits. The side walls, especially the radial, are pro-

vided with simple pits, though often few in number, and this feature serves to a large extent, to assist in their differentiation from adjacent tracheids of similar form (Figs. 36 & 38). It nevertheless not infrequently happens that in transitional forms, such as are met with in *Sequoia sempervirens* (Fig. 37*c*), bordered pits occur on the lateral walls.

The resin is in all cases massive and often very abundant.

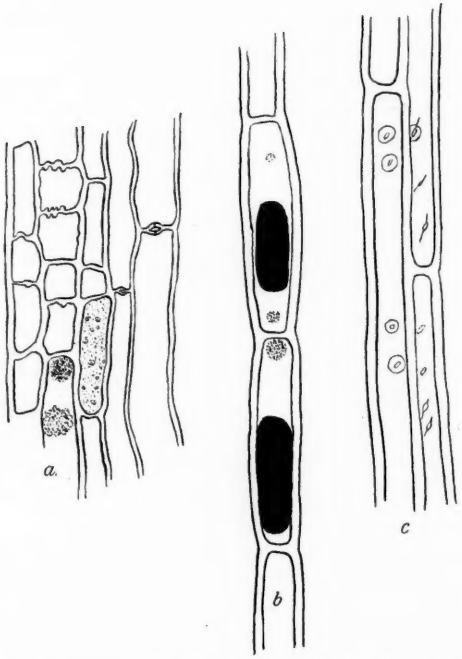

FIG. 37.— *Sequoia sempervirens*. Radial sections showing (*a*) the form of the resin cells and the associated parenchyma tracheids; (*b*) resin cells from the spring wood showing the form of the resin; (*c*) resin cells showing transitional forms with bordered pits. × 200.

In such genera as Taxodium or Sequoia it completely fills the entire cell cavity (Figs. 39 & 40), but in Larix, Tsuga and Pseudotsuga it takes the form of a peripheral layer in immediate contact with the inner face of the cell wall (Fig. 42). The reduction thus indicated is, in some species, carried to such an

extent that the resin is barely recognizable, while in Abies it is wholly wanting.

A relation of more than ordinary interest is to be found in the relation of the resin cells to certain forms of tracheids. In *Sequoia sempervirens* it commonly happens that the resin cells lie in immediate contact with tracheids of special form. These structures are wholly unlike the wood tracheids among which they are found, but they are, in all essential respects, like the tracheids of the medullary rays. They have the form of long, cylindrical elements with abrupt terminations, and they thus bear an external resemblance in form to the wood parenchyma cells with which they are associated. They differ, however, in the distinguishing presence of bordered pits upon their side and terminal walls (Fig. 38*a*). The relations of these two elements is nevertheless a much more intimate one than is implied by mere association. In Sequoia an interchangeable relation is manifested as already pointed out, in the occurrence of resin cells with bordered pits (Fig. 37), while in *Abies amabilis* (Fig. 38) resin cells and tracheids also form a coterminous series. It is thus obvious that we have here precisely the same interchangeable relations that have been found to occur in the medullary rays, and it is evident the one element must arise through modification of the other. The precise order of this sequence is not altogether clear from the available data, but the fact that ray tracheids are derived from their associated parenchyma cells, and that in such types as Podocarpus, Taxodium, etc., the resin cells occur without tracheids, while the latter do occur in Sequoia and especially in Abies, seem to justify the inference that here also they are derived forms, having their origin substantially in special modifications of the parenchyma elements. In view of these relations, it is necessary to distin-

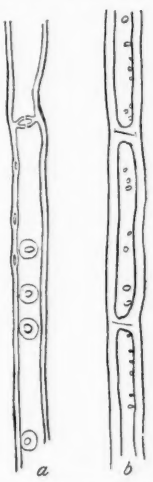

FIG. 38. — *Abies amabilis.* Radial section showing (*a*) the structure of the parenchyma tracheids ; (*b*) the structure of the resin cells : *a* and *b* being normally coterminous. × 200.

guish such elements as *parenchyma tracheids* in order to establish their proper identity and differentiate them from the wood tracheids, which have a wholly different origin, as well as from the ray tracheids, which have a wholly different location. It is probable that the parenchyma tracheids also serve a similar purpose to the ray tracheids with respect to the distribution of nutrient fluids. The origin of the parenchyma tracheids as suggested finds support in the statement of Eichler (11) that the wood parenchyma arises through the activity of the cambium cells, abundantly in the Cupressineæ and Abietineæ, forming in exceptional cases the epithelium of the resin canals, since it at the same time shows how the parenchyma tracheids arise and how they may be intimately connected with the wood-parenchyma; but it finds additional support in a knowledge of the genesis and structure of the resin passage.

In Sequoia and Abies we have two genera which are remarkable for their transitional forms of structure, affording a fairly clear conception of the genesis of the resin passage. In each case there is a well defined tendency toward the aggrégation of the resin cells into compact groups which take the form of longitudinal strands, enclosed on all sides by the accompanying parenchyma tracheids. Under such circumstances the individual cells undergo a continual reduction in length until they eventually become but two or three times longer than broad, or they may even become isodiametric. This change is not accompanied by any alteration in the thickness of the walls in the earlier stages of development, but as a result of such a shortening the effect is to bring about the concentration of a greater number of simple pits within a given area. Such cells, therefore, are always more strongly pitted than those which are isolated and of greater length. When aggregates of this sort have attained to a certain degree of development a line of cleavage arises in the center of the mass and results in the formation of an intercellular space which, according to Eichler (11), always arises schizogenously. This space is short and either isodiametric or but little longer than broad, the length coinciding with the principal axis of growth. Such cyst-like reservoirs or sacs represent the primitive form of the resin canal, and they

are typically developed in Sequoia, Abies and Tsuga. They always form a continuous series extending in a direction parallel with the axis of growth; but as the type of reorganization advances they merge, forming a continuous canal such as may be found typically in Pseudotsuga or Pinus. From these statements, then, it is clear that the parenchymatous resin cells undergo modification in two directions, passing into parenchyma tracheids, on the one hand, and on the other becoming shorter

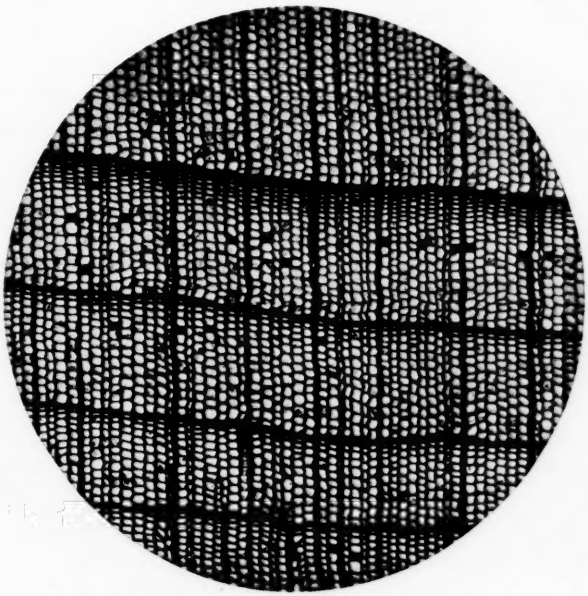

FIG. 39.—*Thuya dolabrata*. Transverse section showing the scattering distribution of the resin cells. × 55.

and shorter, according to conditions of aggregation, until they pass into short cells which eventually constitute the epithelium structure of the somewhat complicated resin passage, the latter thereby becoming the expression of a peculiar aggregation of resin cells. Whatever the stage of development may be, the resin passage is always found to be composed of structural elements arranged in the following order from without toward the center: (1) parenchyma tracheids, (2) resin cells eventually

forming an epithelium and (3) the central reservoir in the form of a cyst or canal. This structure is fully exemplified in the genus Pinus, where the highest form of development is attained.

While the occurrence of resin cells in particular genera is a feature of great taxonomic value, their importance in this respect is greatly emphasized by the particular form of their distribution and the constant tendency they exhibit toward the formation of definite aggregates. In Thujopsis and Cryptomeria (Fig. 39)

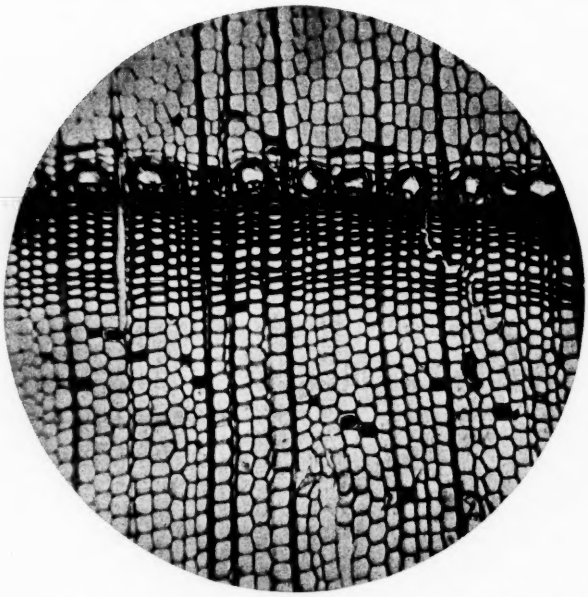

FIG. 40.—*Sequoia sempervirens.* Transverse section showing scattering resin cells in the spring wood, and contiguous resin cysts with aggregates of resin cells on the outer face of a growth ring. × 55.

the resin cells are always scattered throughout the entire transverse section and they show no tendency to the formation of aggregates. In Podocarpus, where there is a notable increase in numbers, the same general law of segregation prevails, but there is nevertheless a somewhat well defined tendency toward aggregation. In Thuya 66.6% of the species show definitely scattering cells, 33.3% show the cells to be scattering with a

tendency toward a more compact disposition, while in 33.3 % the cells fall into well defined aggregates or an approximation to such an arrangement. The genus Sequoia is characterized chiefly by the widely scattering distribution of the resin cells (Fig. 40), but in *S. sempervirens* there are individual cases in which there is also a definite aggregation into groups. In Cupressus 53.9 % of the species are distinguished by the presence of widely scattering cells which become definitely arranged in

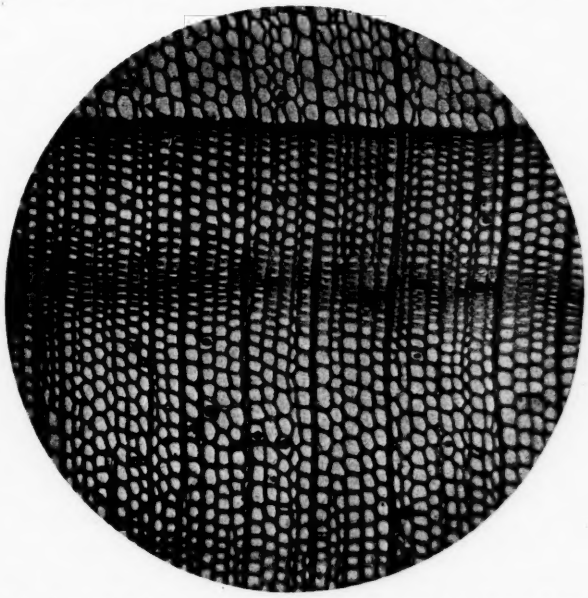

FIG. 41.—*Taxodium distichum.* Transverse section showing the resin cells forming a definite zone. × 55.

zones in 38.4 %, and aggregated into groups in 7.7 % of the species. It will be observed here that this feature of distribution is, on the whole, more pronounced in the relatively primitive genera, and that it diminishes in force in the genera of a relatively high order.

In Taxodium (Fig. 41) and Libocedrus, both of which are distinguished by the presence of very prominent resin cells, these structures are disposed in well defined zones which are concen-

tric with the growth rings and lie either in the spring or summer wood, or in both. This is to be interpreted as a definite tendency to aggregation which is nevertheless not fully expressed, since in each case there are numbers of cells which are not zonal in their distribution, but which conform to the law applicable to Thujopsis and Podocarpus. In Juniperus the cells are typically zonate, being also scattering in only one species. In Abies only 63.6 % of the species bear resin cells. These are

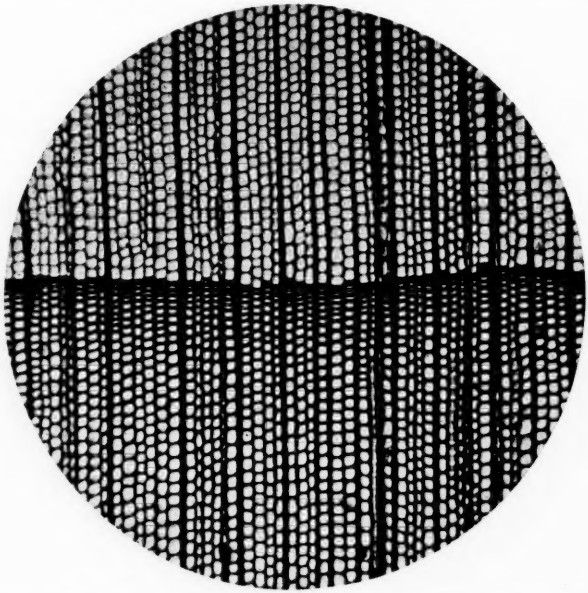

FIG. 42.— *Tsuga pattoniana*. Transverse section showing the distribution of the resin cells on the outer face of the summer wood. × 55.

neither scattering nor zonate in the sense of the previous types, but it is to be observed that in 50 % of such cases, or in 36.3 % of all species, they are aggregated in groups as a preliminary step to the formation of resin passages. On the other hand, 36.3 % of all species show the resin cells to be few, inconspicuous, non-resinous and scattered along the outer face of the summer wood. This, for reasons which will appear more fully later, is to be regarded as a phase in distribution leading to the final

obliteration of such structures, which is fully accomplished in 36.4 % of all the species as represented by *A. balsamea, A. fraseri, A. lasiocarpa, A. veitchi.* This last form of distribution is wholly typical of Tsuga (Fig. 42), in which there are no other resin cells than those on the outer face of the summer wood. Finally, in Picea and Pinus, there are no separate resin cells in any of the situations described, since they have been completely replaced by highly organized resin passages. It thus appears that the distribution of the resin cells presents four variants which bear a direct relation to the organization of resin passages, as the latter eventually replace the former. These facts will appear somewhat more clear from the following summary :

TABLE SHOWING PERCENTAGE DISTRIBUTION OF RESIN CELLS.

	No. of species.	% of occurrence.	Scattering.	In zones.	Grouped.	On the outer face of summer wood.
Ginkgo . . .	1	000.00				
Agathis. . .	1	000.00				
Araucaria . .	3	000.00				
Torreya . .	3	000.00				
Taxus . . .	4	000.00				
Thujopsis . .	1	100.00	100.00			
Cryptomeria. .	1	100.00	100.00			
Podocarpus .	1	100.00	100.00	(100.00)		
Thuya . . .	2		66.60			
	1 = 3	100.00		33.30		
	1		(33.39)			
Sequoia . .	2 = 2	100.00	100.00			
	1				50.00	
Cupressus . .	7		53.90			
	5 = 9	100.00		38.40		
	1				7.70	
Taxodium . .	1	100.00	(100.00)	100.00		
Libocedrus .	1	100.00	(100.00)	100.00		
Juniperus . .	11 = 11	100.00		100.00		
	1		1.10			
Abies . . .	4 = 7	100.00				36.30
	5				45.50	
Tsuga . . .	2 = 5	100.00			33.30	
	5					100.00
Pseudotsuga .	2	100.00				100.00
Larix . . .	4	100.00				100.00
Picea . . .	10	000.00				
Pinus . . .	41	000.00				

Figures in parentheses refer to exceptional forms of occurrence.

From such data it is clear that the distribution of the resin cells bears an important relation to the recognition of sub-generic groups and even of species. But viewing these structures from the broader standpoint of the Coniferales as a whole, it is obvious that they must be placed among the structural elements which belong to the first rank for taxonomic purposes.

We are now in a position to determine what relation, if any, such resin bearing elements bear to questions of phylogeny, and we may first of all consider the resinous tracheids. These structures have been seen to be peculiar to Agathis, Araucaria, and Abies, in which they occur only in certain species. In answering this question, we cannot avail ourselves of evidence derived from fossil plants, since it is in such cases of a negative character. Neither Cordaites nor Araucarioxylon affords definite proof of the presence or absence of such structures, since they do not appear in any of the published diagnoses, and our own studies have not resulted in their recognition. If originally present, they must have been obliterated in the course of fossilization. We must therefore depend entirely upon such evidence as is afforded by existing species. From this point of view it is obvious that they furnish no evidence as to the origin of either of the three genera in which they occur. It is, on the other hand, possible to determine from other data, that both Agathis and Araucaria are much inferior to Abies in point of structural organization and development, and from this we may be permitted to conclude that the resin tracheids of Abies are vestigial forms of elements which were typically developed in Agathis and Araucaria, and possibly characteristic also, of their progenitors. If such inferences are to be regarded as justifiable, they go far to support the idea of a common origin for all three genera, and they thus lend force to conclusions which lead to the same result, but upon the basis of independent data.

From a study of the distribution of the resin cells, it is apparent that they fall into four categories in which the typically segregated cells may be held to represent the most primitive form of disposition. This view is greatly strengthened by the observation that in all such cases, the resin cells are rarely if at all accompanied by parenchyma tracheids, while the structure of

the cell is farthest removed from that which is found to enter into the composition of resin passages, whence they are also to be regarded as of a primitive character. This view is supported by the observed fact that those genera and species in which such segregations occur, are also of a relatively primitive type. With an advance in organization, there is a tendency to the formation of aggregates as expressed in the zonal distribution of Taxodium, Libocedrus or Sequoia, where we also find the definite formation of groups of cells which later exhibit the initial stages in the formation of a definite canal. But in Sequoia, as also in Abies where similar changes take place, the more complete aggregation of the cells is invariably accompanied by structural alterations whereby they become greatly shortened and more strongly pitted, while they are always accompanied by parenchyma tracheids with which they are interchangeable. In this connection it is also to be noted that the aggregates in Sequoia, Abies and Larix leading to the formation of resin sacs, are always disposed in a zonal manner, conformably to the zonal disposition of the separate elements, a relation which is in direct harmony with the view already advanced, that the zonal disposition of the isolated cells is an advance upon the strictly segregated form, and that it leads directly to the formation of resin passages. Following upon the zonal distribution, a more complete aggregation results in the formation of local groups of short, resin cells ultimately leading to the formation of a true resin canal. Such a feature of distribution, occurring in genera which, from other data, may be shown to be relatively high in development, is in itself significant; but we further find that the scattering, zonal and grouped forms bear such relations to one another, that the real succession is in the order already given. Thus while both species of Sequoia are characterized by scattering cells, *S. sempervirens* also shows them aggregated to form groups and eventually imperfectly organized resin canals. Or in Cupressus, the transition is expressed in a more complete form, involving all three modes of distribution. In Tsuga there is an obvious tendency toward the elimination of the resin cells which are now greatly reduced in numbers and confined to the outer face of the summer wood. In Abies a similar tendency is also manifested,

but it is expressed in a different way, and just here we must note a fact of more than ordinary significance. Resin cells are present on the outer face of the summer wood in *A. grandis*, *A. concolor*, *A. amabilis* and *A. magnifica*. Groups of resin cells are present in *A. nobilis*, *A. concolor*, *A. bracteata* and *A. firma*, but it will be seen that in only one case — *A. concolor* — are the two forms of distribution presented in the same species. This is in direct conformity with the idea that the resin passage eventually displaces the resin cell, bringing about an obliteration of the latter, and it goes far to support the idea that with respect to these particular structures, the genus Abies occupies a transitional position, standing next to Picea and Pinus, from both of which the resin cells have completely disappeared. Furthermore, from another point of view, the gradual replacement of the resin cells appears to be indicated by a corresponding reduction in the contained resin. Nowhere is the resin so abundant in the resin cells, as in those genera like Podocarpus and Taxodium, which show no development of resin passages, even in their most simple forms; but with the development of resin sacs, as in Abies or Sequoia, or of resin passages as in Larix and Pseudotsuga, there is a remarkable diminution of the resin, apparently in direct response to its more ready production by more specialized structures.

The genus Abies then, appears to form a transition group, having parallelisms with Agathis and Araucaria through the occurrence of resinous tracheids; with Thuya, Cupressus, etc., through the survival of isolated resin cells approaching obliteration; with Tsuga, Larix and Pseudotsuga through the development of rudimentary resin canals leading to the formation of definite resin passages; and with Sequoia through the survival of isolated resin cells and the development of rudimentary resin canals. Through these parallelisms the connection appears to be most direct on the one hand with Sequoia, and on the other with Tsuga. This relation of Sequoia to Abies has been shown by Penhallow on former occasions (38), and has more recently been indicated in other ways by Jeffreys (24), but so far as the present evidence is of value, it would not permit us to infer that Sequoia, Abies and Tsuga form a continuous and coterminous.

series in the order given, but rather that they represent separate, though short, side lines of development, between which the general sequence is manifested.

Resin Passages.

Structural.

Our studies of the resin cell have shown how peculiar aggregates of these structures lead in a natural way to the organization of resin passages, the structure of which it is now necessary to discuss somewhat in detail, and in doing so it will be most profitable to have reference to (1) the primitive form, (2) the intermediate form and (3) to the advanced or fully organized form.

The primitive form of the resin passage is to be found in Sequoia, Tsuga, and Abies and inasmuch as within these genera they exhibit differences in organization which correspond approximately to the sequence given, it will be necessary to discuss them somewhat in detail, with special reference, however, to Sequoia. This genus possesses special interest with respect to the occurrence and organization of secretory reservoirs, since it is in all probability not only the most ancient genus in which such structures occur, but it is, so far as I am aware, the only genus affording special data with respect to important variations of structure and mode of occurrence. Being also, on the whole, the most primitive of the three genera, I shall deal with it first.

In *Sequoia sempervirens* the secretory reservoirs occur in rows within the initial layers of the spring wood, and they therefore lie exactly on the outer face of the summer wood of the previous year. Within this row the reservoirs are contiguous and in many cases they become confluent so as to form a more or less extended and continuous compound reservoir lying tangentially. In their most rudimentary forms they present the aspect of simple aggregates of resin cells without any differentiation of a resin sac or of an epithelium. In a more advanced stage of development there is produced a central cavity in the form of an intercellular space (Fig. 43, *C*) which has obviously

originated schizogenously. About this the resin cells are generally flattened radially and disposed in such a manner as to suggest the future development of a definite, limiting layer or epithelium. In the completed form of the structure the central space has broadened out and taken a circular form, assuming the character of a definite cyst bounded by as definite a limiting epithelium in which the cells are always flattened radially and disposed concentrically (Fig. 43, *C*). Externally to these cells there may be a second layer of similar resin cells, constituting the outer epithelium, while the whole is enclosed on three sides by a layer of parenchyma tracheids which are exceedingly like

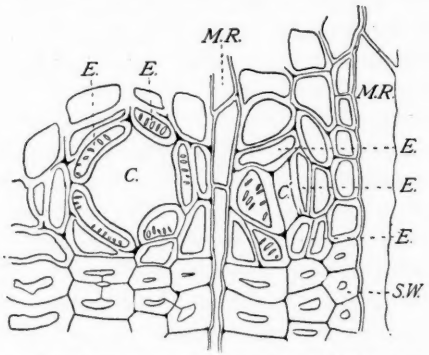

FIG. 43.—*Sequoia sempervirens.* Transverse section showing two contiguous resin cysts, *C*, completed and with a normal epithelium *E*; *C'* an intercellular space as the rudiment of a cyst with imperfectly developed epithelium.' *M. R.* the medullary ray; *S. W.* the summer wood. × 225.

the associated tracheids ot the spring wood, but from which they may usually be distinguished by (1) their greater size and relatively thinner walls, (2) the occurrence of bordered pits on the tangential and terminal, as also upon the radial walls. Such parenchyma tracheids never occur in the adjacent summer wood for very obvious reasons, but on the radially opposite side of the reservoir they are very commonly flattened radially (Fig. 43), and they not infrequently present the same structural aspects as the epithelial cells. The interchangeable relation between resin cell and parenchyma tracheids as already shown would lead us to suspect a substitution in the composition of the epithelium, and

such substitution does actually occur, since it is often to be noted that the second and third rows may be made up, at least in part, of tracheids.

In a longitudinal radial section the reservoir is found to have the form of a sac of varying form and size, but generally elongated parallel with the axis of growth and completely closed at both ends (Fig. 44). The epithelium which immediately defines the limits of the sac generally consists of short, cylindrical cells, while in the second or outer layer the cells become much elongated and several times longer than broad. Beyond this, the third layer consists of parenchyma tracheids readily distinguishable whenever the terminal walls lie near the plane of section, or otherwise as already indicated. Certain deviations from this typical structure require examination. The resin sacs are placed in vertical series of indeterminate extent, but at varying intervals of such a nature that they may sometimes be separated only by a rather thick wall of short resin cells. At other times they are somewhat distant and separated by an extensive vertical tract of resin cells. From this it is obvious that in any given plane of section there will be a great diversity of aspects presented, but in the main exhibiting structural gradations in the development of the reservoir as already recounted. In some cases thick-walled cells of circular outline may be seen

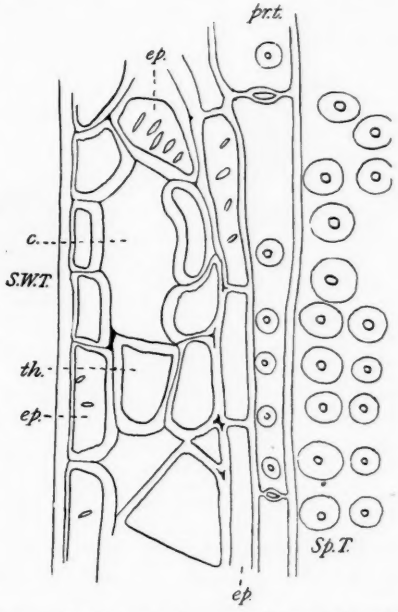

FIG. 44.— *Sequoia sempervirens.* Radial section of a resin cyst, showing the epithelium (*ep.*); the central cyst (*C*) with a thylosis (*th*); parenchyma tracheids (*pr. t.*), and a tracheid of the spring wood (*Sp. T.*). × 300.

in transverse section to stand out from the general line of the epithelium and lie within the cavity proper. More rarely such cells are so multiplied as to fill the entire cavity, and they may themselves be filled with granular resin. Such features are

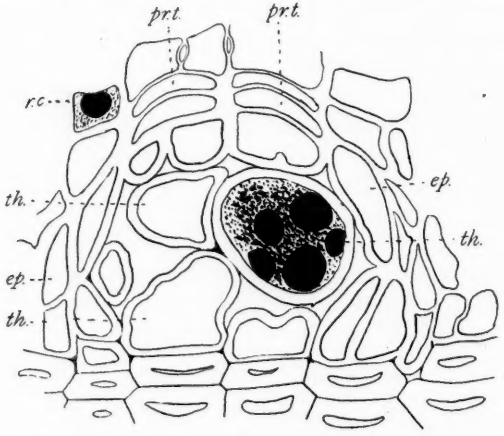

FIG. 45.— *Sequoia sempervirens.* Transverse section of a resin cyst showing an associated resin cell (*r. c.*); the epithelium (*ep.*); the thyloses (*th.*), one of which contains resin, and one of which is directly derived from an epithelium cell; the parenchyma tracheids (*pr. t.*). × 300.

clearly defined (Fig. 45), and it is evident from the way in which such cells originate from the epithelial cells that they are of the nature of thyloses. A longitudinal section through such a reservoir (Fig. 46) shows how such thyloses occupy the entire cavity of the cyst, while in other cases they may be purely local (Fig. 44). Among fossil sequoias similar thyloses form a most characteristic feature in the resin passages of the medullary rays in *S. burgessii.*

In *Tsuga caroliniana* there are no secretory reservoirs, but just in the region between the spring and summer wood of the same growth ring there are peculiar aggregates of resin cells of a more or less rounded outline but forming a continuous series of considerable extent. An analysis of these aggregates shows them to be composed of thick-walled and rounded resin cells, among which there may be a small central intercellular space without any definite organization of epithelium. In such aggre-

gates the component cells are far less resinous than the isolated resin cells of the same section. The parenchyma tracheids are not clearly distinguishable from the associated wood tracheids. In radial section the cells are seen to be very variable, thick-walled and sometimes with more or less prominent intercellular spaces. Between the rays they are several times longer than broad, but opposite the rays they are short, cylindrical and more copiously pitted: while sometimes they may be seen to merge into ray elements and thus to continue their course at right angles to their primary direction. A careful comparison of these cell aggregates with those of Sequoia and Abies leaves little room for doubt as to their structural and functional identity, and we cannot do otherwise than conclude that they represent the most primitive structural condition which is capable of directly giving rise to definite cysts by central cleavage.

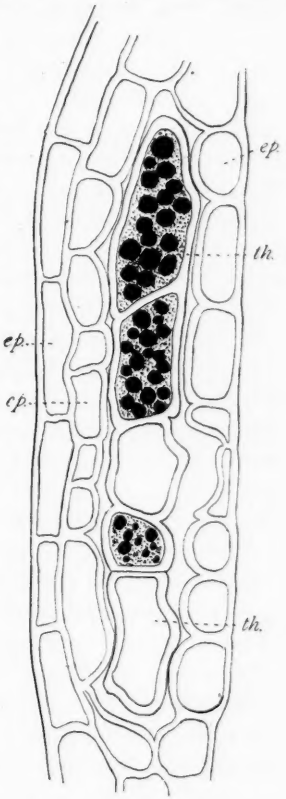

FIG. 46 — *Sequoia sempervirens.* Radial section of a resin cyst showing the epithelium (*ep.*), and the thyloses (*th.*) which completely fill the cyst, and several of which are resinous. This figure corresponds to Fig. 45. × 225.

In *Tsuga mertensisana* the secretory reservoirs are disposed like those of Sequoia, on the outer face of the summer wood, where they form tangential series. They exhibit all the gradations from simple cell aggregates without a central space to perfectly formed cysts with a definite epithelium. This latter is in one, more rarely in two rows, and it is composed of more or less rounded or radially flattened elements. The parenchyma tracheids are few in number, and they are not readily distinguishable from the adjacent wood tracheids. In

longitudinal section the reservoirs are variously rounded or oblong cysts, contiguous or isolated, and forming a longitudinal series. In their general form and structure they are essentially the same as in Sequoia.

In the genus Abies secretory reservoirs occur in at least four species where they form more or less extensive tangential series, within which they are usually contiguous and more or less confluent. They present the same general variations in structural organization as in Tsuga and Sequoia, but in *A. concolor*, and less conspicuously in *A. nobilis*, they are often extended in a radial direction so as to become narrowly oval or oblong, and several times longer than broad. The epithelium consists of a well defined structure composed of one to three rows of cells. The first row, immediately bordering upon the canal, consists of rounded or oval and thick-walled cells which are much smaller than those of Sequoia, and similar to those of Tsuga. They are always characterized by an abundance of strongly defined, simple pits, and many of them contain resin, which usually takes the form of rounded granules of diverse sizes. The parenchyma tracheids are so nearly like the accompanying wood tracheids as, in some cases, to be separable with some difficulty, but they generally surround the resin sac, at least within the limits of the spring wood, and they not infrequently replace the parenchyma cells of the epithelium more or less completely. Not infrequently they form somewhat extended radial series from the epithelium into the spring wood, as in Picea (Fig. 48). In such cases they are usually recognizable by their rather unusual size and thinner walls, and in addition they commonly show bordered pits on the tangential walls. When the terminal wall lies sufficiently near to the plane of section, it shows from one to several rather large bordered pits, and by this feature such tracheids may be located with much certainty. Thyloses have been definitely noted only in the case of *A. concolor*, in which species they are essentially of the same general character as in Sequoia, They are thick-walled and either isolated or so numerous as to fill the entire cyst. In one case of contiguous cysts, an epithelial cell was found to form thyloses in both cysts — in the one case giving rise to an isolated cell, in the other forming a tissue which nearly filled the entire cavity.

In radial section the reservoirs are round or oblong cysts variable size, and they are either contiguous or distant. In the former case they rarely or never become confluent, but they maintain their separate identity as in Sequoia and Tsuga. In the latter case the intervening region is occupied by an aggregate of resin cells in all essential respects like those in the same regions of Sequoia and *Tsuga mertensiana*, or like the aggregates which are generally characteristic of *Tsuga caroliniana*. The inner epithelium usually consists of short, cylindrical and strongly pitted cells which, in the second and third rows, become successively longer and less strongly pitted, so that those in the outer row may be identical in form and markings with the isolated resin cells. In the two outer rows the cells not infrequently show bordered pits on their radial walls, thus presenting transitional forms which gradually pass over into tracheids, and the one then replaces the other. The parenchyma tracheids, which are always most characteristic of the spring wood, are always distinguished by the presence of large and prominent bordered pits, but in addition they are sometimes broad and thin-walled, and lie in radial series.

From these facts it is clear that the secretory reservoirs of the three genera in question always take the form of closed sacs, which DeBary has already pointed out as a feature of certain Coniferæ (9, p. 440), and in order to clearly differentiate them from those which occur in the higher Coniferæ, I shall reserve for all such cases the term *resin cyst*. That such sac-like reservoirs represent the primitive form of the resin passage scarcely admits of question when we observe the various transitional forms which they present and the relation they bear to the resin passages of the higher Coniferæ — a view which is strengthened by the observation of DeBary (9, p. 443) that primitive forms of the secretory reservoir occur in the pith of Ginkgo in the form of elongated sacs.

DeBary has shown (9, p. 440) that the secretory passages traverse the wood longitudinally, at first as prismatic tubes which usually acquire a round or elliptical, transverse section. This statement is applicable to Pseudotsuga, Larix, Picea and Pinus, but inasmuch as there are important differences of detail between

the first three genera and the last, in such a way that the former represent an intermediate, while the latter represents a completed type, it will be necessary to examine them separately. In all of these cases, however, the secretory reservoir is invariably characterized by the presence of a definite and continuous canal of indeterminate length, in consequence of which I reserve for them the appropriate and long used term, "resin passage," as distinguished from the resin cysts of the previously discussed genera.

In Pseudotsuga the resin passages are always scattering, though they frequently occur in tangentially extended groups of two or four contiguous or even coalescent reservoirs. The central canal, which is usually small and not infrequently very narrow, is rather more generally rounded than in previous types. The epithelium is very clearly defined and consists of one to three rows of thick-walled parenchyma cells, sometimes containing resin, the first row of which are rather small and radially flattened, but in *P. macrocarpa* they are rather thin-walled. In *P. douglasii* the epithelium is commonly extended on the two sides of the resin canal in such a way as to form a tangentially elongated tract which not infrequently extends beyond and involves neighboring medullary rays. In *P. macrocarpa*, on the other hand, the epithelium is concentric with the canal, thus forming a tract of about equal thickness all around. Such a deviation as is expressed in *P. douglasii* constitutes the first evidence of a tendency in development which is fully and frequently expressed in Pinus. Thyloses are of infrequent occurrence, and they appear to be confined to *P. macrocarpa*, where they are few in number and generally rather thin-walled. Parenchyma tracheids are usually not apparent in a transverse section. This results from the frequent location of the resin passages in the summer wood, which is not favorable to their development, and from the close resemblance which they bear to the tracheids of the spring wood; and while such elements form an integral part of the resin passage, their particular disposition cannot be exactly defined, though there is no good reason for supposing that they differ in this respect from what may be observed in other cases. In a longitudinal section the

canal is found to be more or less continuous, though it presents frequent constrictions, and it is thereby reduced to very narrow dimensions. It is this feature which causes the canal to exhibit such marked variations in size when seen in transverse section. The epithelium cells are narrowly cylindrical and rather long and thick-walled, as well as somewhat strongly pitted. Outwardly they become much longer and relatively narrower, and they eventually merge with the surrounding parenchyma tracheids by which they may also be replaced.

In Larix the same features of contiguity and coalescence may be observed, except that in *L. occidentalis* the resin passages sometimes form into continuous zones of imperfectly organized structures with the aspect presented in *Tsuga martensiana*. The epithelium is always well defined (Fig. 47) and it consists of one, sometimes two, rows of cells. The cells of the first row are small, very variable in form and size, thick-walled and more or less strongly flattened radially. They are also commonly resinous and more or less strongly pitted. When there is a second row of epithelium, the cells are essentially like the wood tracheids, and like the parenchyma tracheids from which they may be separated with difficulty. The latter, therefore, which are absent from the summer wood, can be distinguished from the elements of the spring wood only when the pits on the terminal walls (Fig. 47 *pr. t.*) are brought into view, or, more rarely, when the pits on the tangential walls are in evidence. Thyloses rarely occur, and so far they have been noted only in *L. occidentalis*, where they

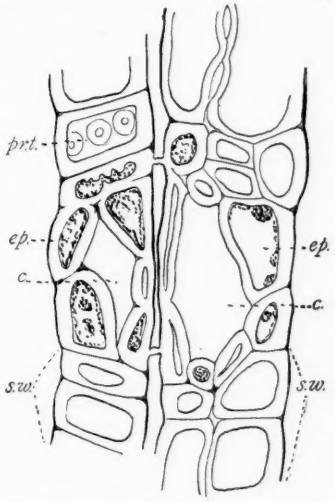

FIG. 47.— *Larix occidentalis*. Transverse section from the inner spring wood showing a pair of resin passages with the central canals (*c*); the thick-walled epithelium (*ep*); a parenchyma tracheid at (*pr. t.*) and the summer wood (*s. w.*). × 300.

are infrequent and thick-walled, and in *L. americana*, where they are of rare occurrence and thin-walled. In longitudinal section the central canal is always continuous, though constricted at intervals, a feature in all essential respects the same as in Pseudotsuga. Radially, the first row of epithelial cells are short cylindrical, or in *L. occidentalis* short fusiform, but there is a graduated increase in length outwardly, so that in the second, or in the third row if present, they become narrow and very long, and they eventually merge with the parenchyma tracheids through intermediate forms with bordered pits. All of the epithelial cells are thick-walled and strongly pitted, and they thus offer a somewhat strong contrast to the rather thin-walled parenchyma tracheids with bordered pits.

The resin passages of Picea differ from those of Pseudotsuga and Larix in being more strictly segregated, and in consequence there is a conspicuous absence of contiguous structures, which may nevertheless sometimes be seen in *P. nigra*, and especially of coalescent forms. They are usually narrow, but well rounded or oval, and there is far greater uniformity of structure and form than in any of the preceding types. The epithelium consists of one row, one to two rows, or even one to three rows of cells, differences which apparently belong to particular species, though no attempt has been made to define the precise limitations of such features. The cells are generally small, round or radially flattened and thick-walled, though occasionally a cell may be thin-walled as in *P. alba*. In cases of thick-walled epithelium, the outermost cells merge with similar tracheids from which they are not readily distinguishable, while the general epithelium becomes extended into a tangentially elongated tract as in *Pseudotsuga douglasii* and Pinus. Thyloses have been noted as of occasional occurrence in *P. nigra*, *P. pungens* and *P. sitchensis*, but they are always thin-walled. Parenchyma trachieds are not obvious in the summer wood, but they are recognizable in the spring wood where they appear to replace the resin cells, though they are apparently of much less frequent occurrence than in the genera previously discussed. In *P. alba*, however (Fig. 48, *pr. t.*), we sometimes find a radial series of tracheids which also extends laterally so as to form an enclosing

layer. Radially the canal is continuous, but with more or less frequent constrictions as in Pseudotsuga and Larix. The epithelium consists of narrow, cylindrical and much pitted cells which increase in length in the outer layers where they become five to seven times longer than broad, and finally they merge with the parenchyma tracheids which replace them.

While the general composition of the resin passage in Pseudotsuga, Larix and Picea is the same as that of the resin cyst, it is obvious that the frequent constrictions in the canal indicate a partial survival of the cystic formation. We must therefore regard these structures and the three genera to which they belong as forming a transition group between the primitive resin cyst on the one hand and the perfectly organized resin passage of Pinus, with its canal of uniform width, on the other.

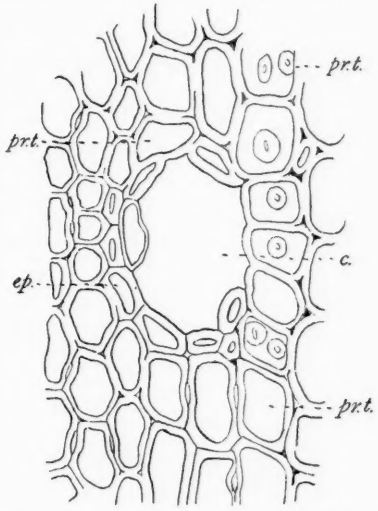

FIG. 48.—*Picea alba.* Transverse section of a resin passage from the spring wood, showing the central canal (*c*); the thick-walled epithelium (*ep.*) and the parenchyma tracheids (*pr. t.*). × 300.

In the genus Pinus, the resin passages show considerable variation in detail, but they all conform to the same structural type (Fig. 49). The central canal is broad and round, often very large, and in longitudinal section it is a perfectly continuous passage of uniform width. The epithelium consists of large, but very variable and thin-walled cells in one to several rows. In the soft pines it generally forms a concentric zone of uniform width, but in several of the hard pines there is a marked tendency to extension in a tangential direction and the formation of rather extensive eccentric tracts. In all of the pines there is a pronounced tendency for the epithelial elements to become so thin-walled that they are readily broken out in

making sections, while in the hard pines, as *P. cubensis*, *P. tæda*, *P. pungens*, etc., the cells are often strongly resinous. In the outer epithelium, the thin-walled elements may be associated with occasional thick-walled elements with which they are interchangeable, precisely as in the similar relations displayed by the medullary rays of *P. pungens* and *P. cubensis*. In the same region also there is a similar association with and transformation

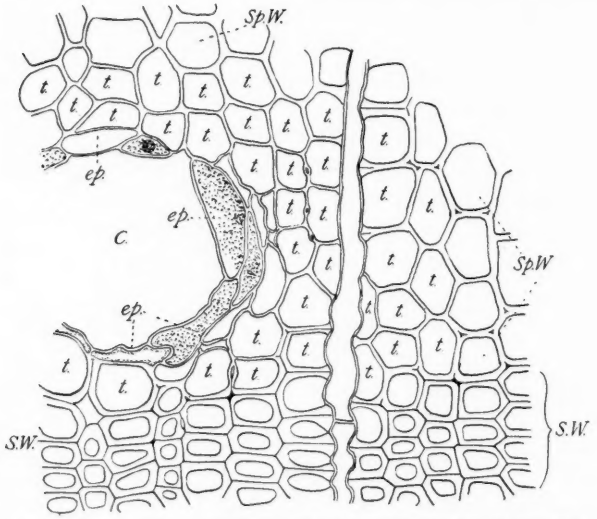

FIG. 49.—*Pinus reflexa*. Transverse section of a resin passage from the inner face of the sping wood showing the central canal (*C*); the thin-walled and resinous epithelium (*ep*); the parenchyma tracheids (*t*); the spring wood (*Sp. W.*) and the summer wood (*S. W.*). × 225.

into parenchyma tracheids, which also has its parallel in the medullary ray. Somewhat more specifically, special reference to two examples may serve to illustrate the general nature of some of the more important variations. In longitudinal section the parenchyma tracheids are usually of much greater length than the associated parenchyma cells, with which they are parallel or coterminous, and they occur in large numbers in *P. lambertiana*. In *P. reflexa* they are coterminous with parenchyma cells which they finally succeed, to be replaced in turn by thin-walled wood tracheids. In *P. lambertiana* they are

always to be distinguished by the bordered pits on the radial, tangential and terminal walls, while in *P. reflexa* they are characterized by the large number of bordered pits on the radial walls, with very few on the tangential walls. In the former situation the pits are much smaller than in adjacent wood tracheids. Together with adjacent wood tracheids, the parenchyma tracheids may be more or less involved in bearing resin (*P. lambertiana*), while finally, as exhibited in transverse section, their numbers may be so large that they form extensive areas about the resin passage (Fig. 49). In such a case the sequence of elements in transverse section would be :—

1. Canal with thyloses.
2. Thin-walled epithelium.
3. Epithelium — cylindrical parenchyma tracheids.
4. Parenchyma tracheids.
5. Wood tracheids with thin walls.

Thyloses are a constant feature in the structure of the resin passages of Pinus (Fig. 30). They are always thin-walled and completely fill the canal. So constant are these features in association with those previously recounted that they serve to afford a ready means of accurately recognizing the genus under all circumstances.

The general course of development thus outlined shows that the parenchyma tracheid stands in such relation to the organization of the resin passage that its more frequent occurrence is directly correlated with a higher type of organization and development in the plants to which they belong.

We are now in a position to present a general summary of the relations which the resin cells bear to the organization of the secretory reservoirs — cysts and passages — and the position which the latter occupy in the economy of the plant, as follows :

1. Resin cells, which are of the nature of wood parenchyma, at first occur as isolated structures filled with resin, but they show a definite tendency to association, and later form definite aggregates.
2. Parenchyma tracheids become associated with such aggregates for the purpose of effecting a more complete nutrition of the secretory cells.

3. Resin cells, when aggregated beyond a certain point, develop schizogenous, intercellular spaces which form either central, closed cysts, or central canals of indeterminate length.
4. The structure of the cyst or passage always presents the same sequence of elements, and the work of the reservoir is then divided between
   (a) the tracheids which provide nutrition for the secretory cells;
   (b) the secretory cells or epithelium in which the formation of the resin takes place;
   (c) the cyst or canal which provides an outlet or storage reservoir for the surplus product;
   (d) the thyloses which may impede the proper storage of the resin, or which may individually serve the purpose of storage.

So long as the formation of resin is not excessive, it is stored in the cells where produced. This is true of all isolated resin cells, as well as of many which enter into the composition of complex cysts and passages. When the resin is excessive, however, the surplus is excreted into specialized reservoirs of the form of closed cysts, or of canals, and we are led to interpret the appearance of these structures in the higher Coniferæ as a response to such needs. The development of the resin passages will thus be seen to stand in direct relation to the capacity of the plant as a resin producer — a fact which is otherwise apparent from our knowledge of the general capacity of the different genera as resin producers, and a comparison of this feature with their known position in the line of descent.

(*To be concluded.*)

A LIST OF BERMUDIAN BIRDS SEEN DURING JULY AND AUGUST, 1903.[1]

HAROLD BOWDITCH.

THE following list comprises those birds which fell under my personal observation on or near the Bermuda Islands between the sixth of July and the twenty-second of August, 1903, the time of my stay at the Bermuda Biological Station. The names of such birds as are included in the Check-list of the American Ornithologists' Union are preceded by their respective check-list numbers, and every effort has been made to bring the scientific names down to date. I wish here to express my thanks to Prof. Edward L. Mark, Director of the Biological Station; Mr. John T. Nichols; Mr. Owen Bryant; Mr. Goodwin Gosling, of Hamilton; and the Messrs. Louis L. Mowbray and R. S. McCallan, of St. George, for their valuable aid in furthering my observations.

70. *Sterna hirundo* (?) Linn. Common Tern.— Terns were seen three times off the north shore, in each case a single individual, but not once was I near enough to make a positive identification. They were in all probability *S. hirundo.*

89. *Puffinus gravis* (?) (O'Reilly). Greater Shearwater.—A Shearwater-like Petrel (family Procellariidæ) was seen in sight of Bermuda, July sixth; it was probably a Greater Shearwater, although certain identification of this bird and of the two others seen on the same day would not be possible without specimens.

109. *Oceanites oceanicus* (?) (Kuhl). Wilson's Petrel.— A "Mother Cary's Chicken" was seen from the S. S. "Gladisfen" on the "Challenger" bank, about twelve miles southwest of Gibbs' Hill, on the first of August. Identification was impossible, but the bird was probably a Wilson's Petrel. Merriam ('84, p. 284) reports finding a Leach's Petrel, dead, on the

[1]Contributions from the Bermuda Biological Station for Research. No. 3.

shore at "'Tuckerstown Beach,' May 1, 1881," and says: "The bird is common enough at sea a hundred or two miles from the Bermudas, but I never saw one near the islands."

112. *Phaëthon americanus* Grant. Yellow-billed Tropic Bird; "Long-tail."— The Yellow-billed Tropic Birds were perhaps the most conspicuous birds in Bermuda until the middle of August, when their numbers seemed to decrease. These birds lay one egg with brown markings, in holes in the cliffs, almost always with no attempt at a nest; as they are very close sitters, many opportunities are offered for study at short range. Mr. Owen Bryant found chicks in the "natal down" on Castle Island on June thirtieth. Eggs were found in Harrington Sound as late as July twenty-sixth, and a downy young bird was found on Brangman's Fort on August twelfth.

I was very much interested in observing the change in the plumage of the young "Long-tail," as seen in many specimens. The bird emerges from the egg covered with puffy white down, shaded with gray on the wings, and has a pale grayish bill, gray feet, and gray, unfeathered lores. This "natal down" is changed for a plumage of white, with black spots on the head, wings and back, and one black spot on the end of each tail-feather. The bill is yellowish flesh-color and grayish; the lores are feathered, and the tail-feathers are all of the same length. During the persistence of this plumage, which in being speckled resembles that of the Red-billed Tropic Bird, the bill becomes yellowish orange, the tint which persists throughout life. The fact that I never saw a speckled bird on the wing, but always on the "nest," leads me to suppose that the speckled plumage is exchanged for a plumage indistinguishable from that of the adult bird, before the bird-of-the-year takes flight; and it seems as if the change could not be due to wear, as the bars and spots of black are almost half an inch from the ends of the feathers.

194. *Ardea herodias* Linn. Great Blue Heron.— I saw one of these birds in Tucker's Town Bay, July fifteenth, and another was seen on an island near Hamilton Harbor on the eighth of August. Capt. Savile G. Reid ('84, p. 242), quoting Major edderburn, says: "In 1846 the nest of this bird, containing two eggs, was found amongst the mangrove trees at Hungry Bay." This is said to be the only known nest-record.

234. *Tringa canutus* (?) Linn. Knot; Robin Snipe.— A single bird, probably of this species, was seen on July twenty-seventh on Cooper's Island, in company with three other waders, a Turnstone, a Spotted Sandpiper, and a supposed Sanderling. All were rather shy and hard to approach.

248. *Calidris arenaria* (?) (Linn.). Sanderling.—One instance, not a positive identification; Cooper's Island, July twenty-seventh.

263. *Actitis macularia* (Linn.). Spotted Sandpiper.—I have only two days' positive records for the Spotted Sandpiper, namely July twenty-seventh, when I saw two or three on Cooper's Island; and July twenty-ninth, two at Hungry Bay. However, Sandpipers were seen on one or two other days, and were probably the Spotted.

274. *Ægialitis semipalmata* Bonap. Semipalmated Plover: Ringneck.— One instance, a single bird on Cooper's Island, August twelfth.

283. 1. *Arenaria morinella* (Linn.). Ruddy Turnstone.— One record, Cooper's Island, July twenty-seventh.

289. *Colinus virginianus* (Linn.). Bob-white; "Quail."—According to Capt. Savile G. Reid ('84, p. 227) these birds were imported from the United States in 1858 or 1859. My records for them extend from July seventh to August twentieth, seldom more than one in a day. I heard the spring call as late as August tenth, and was told that a brood of young was seen near the Hotel Frascati, where the Biological Station was located, shortly before my arrival in Bermuda.

320b. *Columbigallina passerina bermudiana* (Bangs and Bradlee). Bermuda Ground Dove. — This is one of the common Bermuda birds, being found especially in cultivated areas. It is very tame, allowing one to approach within two yards of it.

428. *Trochilus colubris* (?) (Linn.). Ruby-throated Hummingbird.— On July twentieth, as I was driving along the Middle Road, not far from the Whitney Institute, a Hummingbird flew over my head from among some oleanders. As the Ruby-throat is the only Hummingbird that has been taken in Bermuda (Reid, '84, p. 210), the bird that I saw was probably of this species. On July fifteenth another member of our party (Prof. Albert Mann) saw a Hummingbird in the same neighborhood.

488. *Corvus americanus* Aud. American Crow.— Messrs. Bangs and Bradlee (:01, p. 253) say: ". . . . It is, however, doubtful if the Bermuda Crow is *Corvus americanus*. Its notes are said to be different, more like those of the European Carrion Crow (*Corvus corone* Linn.), a hoarse, raven-like croak.

During the season of 1900–1901, crows were seen but seldom and never more than three together at any one time. They were shy and their notes were not heard distinctly."

I have several records, namely: July seventh, several heard calling on Paynter's Hill; July tenth, two heard calling in the direction of Harrington Sound, from the Flatts; August tenth, a flock of seven seen at close range (but not heard) on the South Shore, about opposite the Devil's Hole; August eleventh, three together, seen and heard on the southern shore of Harrington Sound, west of Patton's Point; and August twenty-first, one heard from the Biological Laboratory on the side of a neighboring hill. In neither flight, appearance, nor voice did any of these crows seem to me to differ from *Corvus americanus*, and I heard their cawing distinctly, especially on July seventh and August eleventh. I was told that there were three Crows' nests on Trunk Island, Harrington Sound, and was shown a nest on Cooper's Island on July twenty-seventh, said to have contained young birds earlier in the season.

593. *Cardinalis cardinalis* (Linn.). Cardinal Grosbeak; Redbird.—The "Red-bird" is one of the most abundant of the residents, and I have an almost uninterrupted series of daily records from July seventh to August twenty-second, my entire stay, the single exception being on August first, which was spent on the "Challenger Bank," twelve miles from shore. At Hungry Bay I saw a Cardinal's nest containing three or more young birds, on July twenty-ninth, a late date, for Reid says ('84, p. 201), "As a rule, the two clutches of eggs are deposited about April 10th, and May 30th, respectively." Moseley ('79, p. 25) alludes to the fact that it is an introduced species, and Ridgway says (:01, p. 674), "the species is said to have been *introduced* from the eastern United States"; the date I am unable to determine.

Passer domesticus (Linn.). House Sparrow; "English" Sparrow.— Reid wrote in 1877 ('84, p. 196)[1] of two importations

[1]Reprinted from 1877.

from New York, one "a few years ago," the second in 1874, and says, "I have no doubt they will increase and multiply after their manner, and in time become as much a nuisance as they are now a curiosity." This prophecy has been fulfilled, and I am told that the "English" Sparrows breed in Bermuda at all seasons. The Sparrows are interesting in one respect, namely, the fact that the adult birds, and especially the females, are noticeably lighter and more yellowish than the United States birds. That this is due to bleaching is proven by a specimen taken by my friend, Mr. Nichols. This bird is an adult female, in which the light colored, worn-out tail feathers are being replaced by a new set of typical dark ones.

Carduelis carduelis (Linn.). Goldfinch.—Reid ('84, pp. 196–197) says, "I observed a single specimen of the European Goldfinch, *Carduelis elegans*, near Harrington Sound, in April, 1875; it was very wild, and I could not get near it, but I imagine it must have been an escaped prisoner." This bird is now common in Bermuda, and I did not find it at all hard to approach, in spite of the fact that Bangs and Bradlee (:01, p. 256) state that it "is exceedingly shy and wary." By far the largest flock that I saw was at the Flatts, on August tenth, and contained about thirty birds. On June twenty-ninth Mr. Owen Bryant found a newly built nest of the Goldfinch on Trunk Island, Harrington Sound; it was in a cedar, some twenty-five feet from the ground and six or seven feet from the trunk of the tree. On July sixth it contained four eggs.

611. *Progne subis* (?) (Linn.). Purple Martin.—On August fourteenth, while between Coney Island and the Ferry Reach, I saw two Martins flying past the Martello Tower, southward. I was unable to determine the species, whether Purple or Cuban, but as the range of the Cuban Martin is, according to Chapman ('95, p. 320), "Southern Florida south to Cuba and probably Central America," the birds were in all likelihood Purple Martins. Reid ('84, p. 190) states that this bird "has only .... appeared on one occasion, during the 'entrada' of September, 1849, when it was numerous." I looked this matter up in the "Natural History of the Bermudas," a collection by Miss H. T. Hurdis of scattered notes by her father, John L. Hurdis. His

only records of specimens fall in September, 1849, but he records martins seen by other people three times, viz.: August, 1847 (p. 26); September 19th, 1850 (p. 193); and April 24th, 1851 (p. 212).

631b. *Vireo noveboracensis bermudianus* (Bangs and Bradlee). Bermuda White-eyed Vireo; "Chick-of-the-village."— This bird ranks with the Cardinal and the Catbird in point of numbers; everywhere that one goes, he hears its characteristic song, translated into "chick-of-the-village" by the negroes. Bangs and Bradlee (:01, p. 253) say, "The iris in *V. bermudianus* is *white* as in *V. noveboracensis*, and not "brownish, brownish gray, or gray," as stated by Capt. Reid. This seems to me to be a very hasty conclusion, as I have never seen a Bermuda Vireo with a pure white eye. The birds are very tame and familiar, and I made it something of a point to look at the iris whenever a good opportunity offered, with the result that I saw just two specimens with "dirty white" irides, and these had every appearance of being young birds. The irides of all the other birds of which I took note were dark.

Reid ('84, p. 192) says, "It is on record that the newly fledged young of this species have been found entangled in the meshes of the web of the 'silk' spider, *Epëira* [Epeira] *clavipes*. These webs are of great size and strength, extending for many feet between adjoining cedars, and the number of them among the woods in summer and autumn is almost incredible. In all my rambles, however, I never met with an instance of poor little Vireo having walked into Epëira's parlor."

On the twenty-ninth of July I saw, at the edge of the mangrove swamp at Hungry Bay, a Vireo with a large mass of cobweb on the side of its head, completely covering the right eye. The left eye only was used, which necessitated the bird's turning on its perch in order to watch us, instead of simply turning its head.

704. *Galeoscoptes carolinensis* (Linn.). Catbird; "Blackbird."— Extremely common throughout the islands. During my stay in Bermuda I did not once hear the "mew" which gives the Catbird its name, and the song and the other notes of the Bermuda Catbirds sounded to me not quite identical with those of United States birds.

766. *Sialia sialis* (Linn.). Eastern Bluebird.— A very common bird. Bangs and Bradlee (:01, p. 255) state that the Bluebird is migratory as well as resident, so that "possibly some of" the migrants "remain and breed and thus counteract any tendency to vary that the island birds might develop if wholly cut off from the main body of the species." Reid ('84, p. 175) says of the nests, "I have found them commonly in holes in old quarries or roadside cuttings; also in crevices of walls; in rocks, even when some little distance from the shore; in holes in trees; on the branches of trees; in stove and water pipes; in calabashes, boxes, etc., hung up for them in the verandas of houses, ... and in several other curious situations."

On July tenth Mr. Owen Bryant found a Bluebird's nest containing three young birds, built in the capstan of an old wreck near Coney Island. On the twenty-sixth of July Mr. John T. Nichols and I found some holes in a bank of sand, part of one of the cliffs nearly due north from the Devil's Hole, Harrington Sound; they were some four or more inches in diameter and a foot and a half to two feet deep, and two of them contained nests of soggy vegetable materials, one of which had in it a couple of bad eggs, probably Bluebirds'. This seemed to us a strange nesting site for the bird which we always associate with the hollow limb of an old apple tree.

Besides the twenty-one birds listed above, the following were reported to me:

On July twenty-third Mr. Leon J. Cole saw a Tattler (*Totanus*), probably *melanoleucus*, at St. David's.

During July a large Hawk was seen by various members of the Bermuda Biological Station. His identification as a *Buteo* was all but complete.

On August sixteenth Mr. Louis L. Mowbray told me of a Snowy Owl (*Nyctea nyctea*) which had been seen on the afternoon of the previous day, in the Devonshire marsh. Swallows (probably Barn Swallows, *Hirundo erythrogastra*) were reported common.

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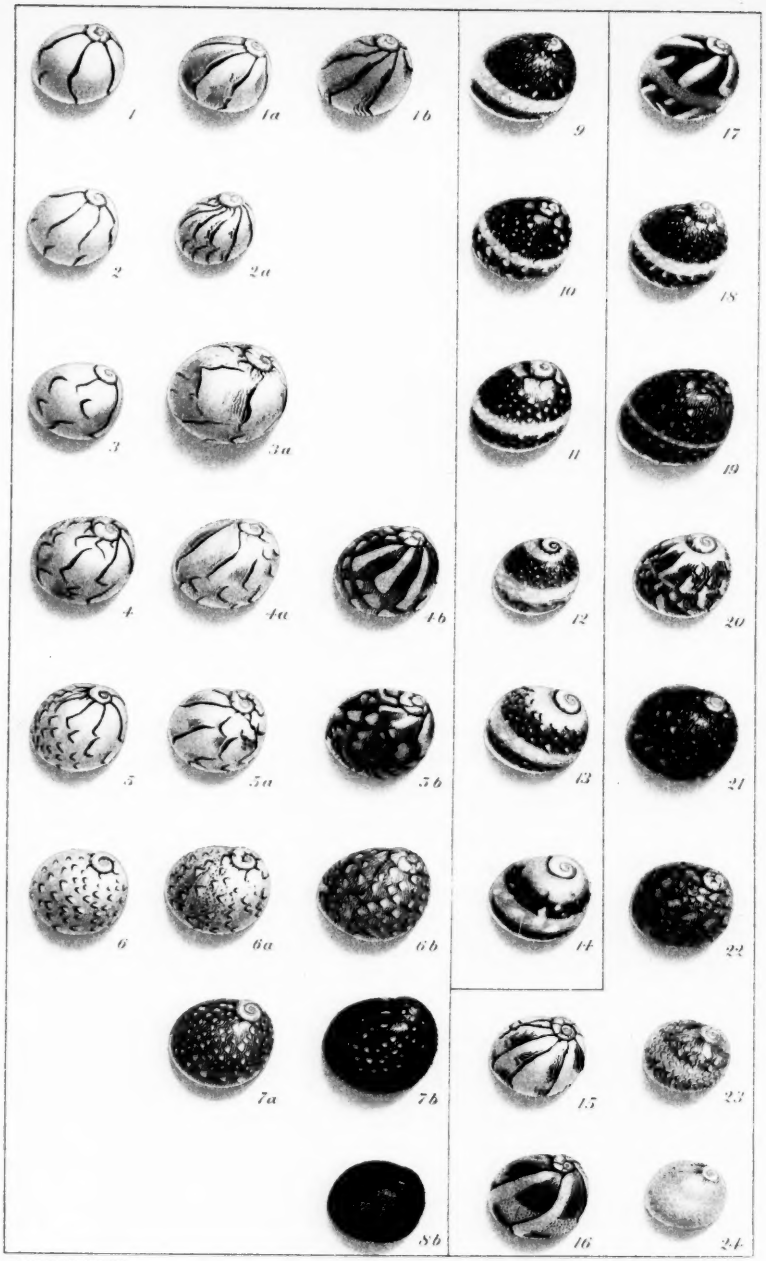
[1] Note.— This paper by A. H. Verrill, seems to have been overlooked by the author.— E. L. Mark.

Neritina virginea. *variety* minor.



x 2 DIAMETERS.

NERITINA VIRGINEA VARIETY *MINOR*.[1]

MAYNARD M. METCALF.

WHILE collecting one summer in Jamaica, W. I., the author visited the "Salt Pond" near Port Henderson. This shallow pond is separated from the ocean by a narrow strip of sand over which the waves break during heavy storms. It has no outlet to the ocean and no fresh water streams flow into it. The water thus comes to be considerably more salt than that of the open ocean. The sample of water from these ponds which the author examined had a specific gravity of 1.038.

The fauna of this pond is quite rich and includes some very interesting forms. One is especially attracted to the beautiful little Neritina which literally covers the beach for rods near the water's edge. From a double handful of these animals scooped up in one spot on a little sand bar near the shore, the author has selected the shells in the accompanying plate. They are arranged for use in another publication and are designed to show a remarkable example of diversity. I would like here to call attention not only to the diversity but also to the dwarfing of these shells and its apparent cause.

Neritina virginea is a widely distributed littoral marine species. Full grown adults from the ocean are of the size of the figures on the accompanying plate. They show the same types of color and color pattern. Other types also are found among both the open ocean shells and those from the Salt Pond, but I have not attempted to figure them.

It is interesting to find that the Neritina of the "Salt Pond" is a dwarf variety. In almost every regard except size the animals resemble their ocean relatives, but their size is much less. The diameter of an average sized shell from the Salt Pond

[1] By the courtesy of The Macmillan Company the author is permitted to use for this article the accompanying plate which he has prepared for use in *An Outline of the Theory of Organic Evolution*, now in press.

would be about half that of an average shell from the open ocean. The figures on the plate are enlarged two diameters.

Apparently the extra salinity of the water in the Salt Pond has dwarfed the animals. That they are not young individuals is indicated by the facts (1) that no individuals of larger size were found, (2) that no smaller ones were found, indicating that they were not breeding at the time these shells were gathered. It can hardly be supposed that both the very young and the adults hide themselves from view, while the half-grown individuals crowd upon the shore in numbers that literally cover the sand at the water's edge. Yet the author should mention that he has seen a letter to Professor E. A. Andrews in which reference was made to these shells, called by the natives *Bossu*, saying that they are used for food and are gathered in fresh water streams at night with lanterns, but that during the day they hide under stones and can be found only with difficulty. There seems little doubt that the form from Salt Pond Neritina is a dwarf variety, and if so, the most probable cause of the dwarfing seems to be the density of the water in which they live.

It is still more interesting to find that a similar dwarfed Neritina occurs in fresh water streams in Jamaica. Professor Andrews has collected them in a small stream at Port Antonio, and the same letter referred to above mentions their occurrence in Mabess River, a branch of Spanish River near Buff Bay. Doubtless they occur in other Jamaica streams.

The author has about five hundred shells collected for him by Dr. F. S. Conant in "a small stream at Port Antonio," probably the same stream in which Professor Andrews saw them. These shells are all small, — no larger than those from the Salt Pond. Among them are some that are very small and apparently immature. Careful search should be made for full sized individuals in these streams before we can be positive that none are present. This the author has been unable to secure. Such data as we have, however, especially in comparison with the Salt Pond conditions, seems to indicate the probability of these fresh water Neritina shells being a dwarf variety.

If this conclusion is correct we have the very interesting phenomenon of an animal normally living in the ocean able to adapt

itself to life in fresh water or to water of greater salinity than that of the ocean, but unable to attain its full size except in the ocean.

The dwarfed forms may fairly be called a variety, though their difference from the ocean forms be only one of size probably directly due to increased or decreased salinity of the water in which they live.

The great diversity in color and in color pattern found in *Neritina virginea* is well known, yet it may be worth while to call attention to the completeness of the intergrading between any two types, however divergent.

Color shade. — Note first the differences in the ground color of the shells: yellow in 5*b*, 19, and 22; white in all the rest. Observe that the colored lines are black in 1, 3, 5, 5*b*, 6, 6*a*, 19, 20, 22; purplish in 6*b* and 11; red in 7*a*; gray in 23; black and red in 2; that the major lines are black and the minor lines red in 1*a*, 3, 3*a*, 4, 4*a*, and 5*a*; that the major lines are black and the minor lines purple in 4*b*, 17 and 16.

Color pattern. — 1 is marked with a few heavy lines. From 1 to 6 these major lines become broken up into small V-shaped loops. In the shells *a* accessory minor lines are added. In the shells *b* these are more numerous.

Series 9 to 14 shows diversity in the pattern near the apex of the coil: 9 has a few slightly larger white dots near the coil, 10 has larger dots here, 11 has them very large; in 12 they have united to form a continuous white band; in 13 and 14 this band is wider.

Series 15 to 24 shows diversity in the character of the equatorial light band. In 15 and 16 only the minor lines are interrupted or faint along the equator of the shell; in 17 the major lines also are interrupted; in 18 the band is almost clear white; 19 and 20 show narrower bands; in 21, 23 and 24 the equatorial band is shown by a difference of color in and under the pattern; in 22 the equatorial line is faintly indicated in the pattern itself, being bordered above and below by large, heavy, black loops.

The shells figured are but a few selected from the large number collected. Other types of color and of color pattern were

found. Between any two of the shells collected, no matter how divergent in type, a completely intergrading series could be found.

It is doubtful if these colors and color patterns are of protective value. The shell is enclosed by flaps of the mantle most of the time rendering the coloration invisible. Also all types of color pattern are seen in one locality. Then, too, the animals are in such great numbers that they could hardly escape the observation of their predatory enemies, if such they have, by means of their coloration.

The shells shown as numbers 5*b*, 8*b*, 19 and 22 are from Port Antonio, probably from the stream in which Professor Andrews found Neritina, a small shaded stream with a dark bottom of vegetable mould. One can readily observe that the shells from the Port Antonio stream are darker than those on the unshaded, light-colored sand beach of the Salt Pond. Few of them resemble numbers 1 to 5 or the *a* shells of the accompanying plate. Most are heavily marked with dark lines, many of the type shown in 8*b* being found. As a whole, the shells from the stream average much darker than those from the Salt Pond. Also it is noticeable that the ground color of almost all of these fresh-water shells is yellow, while that of the Salt Pond shells is white.

Remembering that it is doubtful if the coloration of these shells is to any considerable extent protective, it is interesting to find that the darker-colored shells are found in the midst of dark-colored surroundings, in a shaded stream, while the lighter-colored shells are from an unshaded beach of light-colored sand.

Comparison with the collections of *Neritina virginea* in the United States National Museum and in the Museum of the Philadelphia Academy of Sciences shows that the color of the Jamaica Salt Pond shells averages considerably lighter than that of shells from the ocean, the ground color being a clearer white, and shells of the patterns represented in figures 1 to 6 and 1*a* to 6*a* being present in larger proportion.

Few, if any, finer examples of diversity in color and in color pattern are known. The same types of coloration are found in the full grown shells from the ocean. In the absence of breed-

ing experiments, if it were not for the completely intergrading forms, systematists would probably have no hesitation in recognizing several species. As it is, all must without doubt be included in one species, and it seems hardly worth while to name as varieties (*punctata, lineata, bilineata, trilineata*, etc.) even the most divergent types. The dwarf forms, however, might fairly be called variety *minor*.

The writer would suggest that, if the difficulty of rearing these animals be not too great, it is probable that they would be favorable subjects for breeding experiments.

THE WOMAN'S COLLEGE OF BALTIMORE,
April 25th, 1904.

STUDIES ON THE PLANT CELL.—III.

BRADLEY MOORE DAVIS.

Section III. Highly Specialized Plant Cells and Their Peculiarities.

Very much of our knowledge of the structure and behavior of protoplasm in plants has been derived from the study of certain cells whose organization has reached an exceptionally advanced degree of differentiation. The peculiarities of these cells are obvious and have proved of great interest but we have as yet scarcely made a beginning in the study which must trace and relate these characteristics of the most complex products of cellular evolution in plants to their more simple progenitors.

This section will describe in some detail the structure and protoplasmic activities of the following six highly specialized cells: 1, The Zoöspore; 2, The Sperm; 3, The Egg; 4, The Spore Mother-Cell; 5, The Cœnocyte; 6, The Cœnogamete.

1. The Zoöspore.

Zoöspores are interesting not only for their own peculiarities but also because they are well known to be the progenitors of the sexual cells or gametes which become later differentiated into the egg and sperm. Comparative studies upon three cells so closely related and yet so diverse in their extremes of structure are sure to yield important results.

The zoöspore is generally an uninucleate cell, colorless in the Fungi, but containing a chromatophore or plastids in all other groups of thallophytes. There are usually two or four cilia attached to the anterior pointed end which is free from coloring matter and at this region one may expect to find a red pigment spot. Some zoöspores are exceptional for special peculiarities, as those of Vaucheria which are multinucleate, each nucleus

being accompanied by a pair of cilia, or those of Œdogonium whose colorless forward end bears a crown of numerous cilia. The zoöspore stands among the higher forms for a type of motile organism that is very close to the bottom of the assemblage of groups and developmental lines which make up the Algæ. The forms most closely related to the zoöspore are in the family Chlamydomonadeæ of the Volvocales. But at this general low level of the plant kingdom there are several groups whose members pass most of their lives in motile conditions (Volvocales, Flagellates and Peridinales) and the cells of all of these types resemble zoöspores to a greater or less degree in their structure and habits, so that this condition represents a widespread and well defined stage of evolutionary development. Therefore when zoöspores are formed in the life history of some higher plant they represent a return on the part of the organism for a short time to the structure and mode of life of an ancestry perhaps related in some way to the groups that still have the motile habits throughout most of their existence.

For these reasons close comparisons in structure between the zoöspore and motile Algæ will be interesting and should help to explain the peculiarities of these cells. These peculiarities chiefly concern the organ that forms the cilia (blepharoplast), which becomes very complex in the sperm, and the pigment spot.

Unfortunately studies upon these problems have been few and we are not prepared to make a general statement of the conditions. The most recent investigation on the structure of the zoöspore is that of Timberlake (:02), but Strasburger has written extensively on the subject, especially in the *Histologische Beitrage* ('92 and :00). The later paper (:00, p. 177–215) reviews the entire subject of cilia formation. Dangeard has presented an account of the Chlamydomonadeæ, '99, and in :01 described especially Polytoma, comparing its structure with that of the animal spermatozoan.

Polytoma (see Fig. 9 *a*) is a colorless organism but its cell structure and life history place it unquestionably among the Chlamydomonadeæ. The two cilia arise from a small body (blepharoplast) situated at the extremity of the cell. A delicate

thread-like structure, which Dangeard calls the rhizoplast, extends from the blepharoplast into the cytoplasm and sometimes ends at the side of the nucleus in a granule (condyle). The cilia grow out from the blepharoplast. This apparatus is not known to bear any relation to centrosomes or to the kinoplasm of nuclear figures present at the time of spore formation. But it should be noted that the blepharoplast is situated directly under if not actually in the outer plasma membrane, which is kinoplasmic. The filamentous connection between blepharoplast and nucleus is probably important, especially since it has also been found in zoöspores (Timberlake, :02, for Hydrodictyon) but we do not even know its developmental history much less its function. Further study will be necessary to make clear possible relations to kinoplasm around the nucleus or to centrosomes. Consequently Dangeard's comparison of Polytoma to the animal spermatozoön is not convincing for it seems to be established for the spermatozoön that portions of the middle piece at least and the flagellum are derived from a true centrosome. Indeed from the meager evidence now at hand the blepharoplast of Polytoma is as likely to be a structure differentiated from the plasma membrane as to have any relation to the nucleus. But detailed studies on sporogenesis may discover a history more in harmony with that of Hydrodictyon.

We have summarized a portion of Timberlake's (:02) account of sporogenesis for Hydrodictyon in the previous section under the head of "Cleavage by constriction." We shall consider now certain details. Small spherical bodies are found at the poles of the spindles during nuclear division in the mother-cell. They are undoubtedly accumulations of kinoplasm and perhaps stand for centrosomes. However they have no polar radiations nor could they be followed between mitoses when the nuclei were in resting conditions. It is not probable therefore

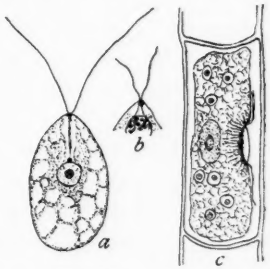


FIG. 9.—The Zoöspore. *a*, Polytoma; *b*, Hydrodictyon; *c*, Development in Oedogonium. (*a*, after Dangeard: 01; *b*, Timberlake: 02; *c*, Strasburger '92.)

that these structures are permanent in the cell. After nuclear multiplication is ended segmentation proceeds until the nucleate masses of protoplasm separate from one another as zoöspores. Then a body may be found lying in contact with the plasma membrane and bearing a pair of cilia (Fig. 9*b*). This basal body (blepharoplast) by its reaction to stains seems to be entirely distinct from the plasma membrane and is connected with the nucleus by very delicate threads. There is a time just previous to the differentiation of the zoöspores when the nuclei lie very close to the cleavage furrow that finally separates the adjacent zoöspore origins. A granule may sometimes be observed close to these nuclei and it is possible that this is the first appearance of the basal body (blepharoplast). If this should prove correct the structure may have a direct relation to the kinoplasm around the nucleus, a relation that is afterwards maintained through the two or three delicate fibers that connect these structures. Thus the blepharoplast if not directly derived from a centrosome may at least have its origin from the same region of kinoplasm. However these possibilities are mere speculations and the investigation of these points is very much to be desired in a number of algal and fungal types.

We are now brought to the views of Strasburger as expressed in his writings of '92 and :00. His investigations have been chiefly on Vaucheria, Cladophora and Œdogonium. In all of these forms the cilia come from a body (blepharoplast) which he believes to arise from the outer plasma membrane (Hautschicht). The nucleus lies close to the plasma membrane at the time when the blepharoplast is formed and may determine its development there as a dynamic center, but the blepharoplast is not a centrosome according to Strasburger. It is of course kinoplasmic since it develops from the plasma membrane and this would accord with its activities as a cilia forming organ. The blepharoplast is extraordinarily large in Œdogonium (see Fig. 9*c*) and develops a ring of numerous cilia on the exterior while at the same time fibrillar rays grow back into the cytoplasm and probably help to give a compact organization to the zoöspore. This structure is very suggestive of the centrosphere and aster that cuts out the ascospore (see Section II, Free Cell

Formation) and in spite of Strasburger's conclusions that it is derived entirely from the plasma membrane we are justified in asking for a fuller description of its development. There is the possibility of a different origin wherein the nucleus may play an important part which, in the light of Timberlake's studies on Hydrodictyon, suggests that Strasburger may not have discovered the earliest beginning of the blepharoplast in Œdogonium. And the same doubts apply to Cladophora and Vaucheria.

There is thus considerable divergence in the views of the origin and nature of the blepharoplast in zoöspores, Strasburger believing that they are developed as a specialized region of the plasma membrane with no relation to centrosomes, and Timberlake holding that the structure in Hydrodictyon is not a part of the plasma membrane but comes from the interior of the protoplasm. The problem is also involved with conditions in the sperm, where there is likewise a difference of opinion as to the homologies of the blepharoplast but an undoubted origin at least in the pteridophytes and gymnosperms from the interior of the cell. We should naturally expect the blepharoplasts of zoöspores and sperms to be homologous and consequently the problem is of great theoretical interest and will be taken up again in our discussion of the sperm. Its solution demands a most thorough study of the development of some of the larger zoöspores as in Œdogonium and certain species of the Confervales and Volvocales.

The pigment spot is almost universally present in zoöspores and is also characteristic of the cells of many motile organisms as in the Volvocales and Flagellates while occasionally found in other groups. The structure has been called an eye spot from its fancied resemblance to the simple eyes of certain Crustacea (Cyclops, etc.) but this term is unsatisfactory since it is not established that the pigment spot is primarily a receptive organ for light or warmth; but even should it prove to be thus sensitive (which is very probable) thereby orienting the cell with respect to the direction of incoming rays, that is not a function comparable to sight.

The coloring matter of the pigment spot is held as a single globule or as a collection of numerous small granules in meshes

of the protoplasm. It is frequently associated with a plastid. The pigment may be readily broken down and dissolved out by such reagents as alcohol and ether. In chemical composition it is very close to hæmatochrome and thus may be related to chlorophyll or a derivative of that substance. The cytoplasm around the pigment spot is undifferentiated and when the coloring matter is removed it is very difficult and sometimes impossible to find the situation of the structure. Consequently the pigment spot can hardly be considered a protoplasmic organ since it is merely an accumulation of coloring matter at some point in the cell. Strasburger (:00, p. 193) states that the pigment spot of certain zoöspores (Cladophora, etc.) is formed in the plasma membrane but this is not true of many other motile cells (Flagellata) and there is no doubt that in some cells (*e. g.* the gametes of Cutleria) the pigment spot is a portion of a plastid. The literature upon the structure and function of pigment spots is reviewed by Zimmermann (*Beiträge z. bot. Centralb.* Bd. 4, p. 159, 1894) and since then Wager ('99) has presented a detailed study of Euglena.

2. The Sperm.

The sperm is unquestionably derived from the zoöspore through primitive types of gametes which were identical with zoöspores in all essentials of morphology. I have described the origin and evolution of sexual cells of plants in two recent papers (*Popular Science Monthly*, Nov. 1901, p. 66 and Feb. 1902, p. 300). We should expect the simplest forms of sperms to have the characters of zoöspores and this is the fact. The sperms of the Algæ, as a rule, have the same number of cilia (usually two) as their ancestral asexual zoöspores. They generally contain a chromatophore, although sometimes much reduced, and there is present the pigment spot. The cilia are attached at the pointed end or at the side, arising from colorless protoplasm that sometimes contains the pigment spot while the chromatophore, when present, and the nucleus lie at some distance from this region of the cell. The sperms of bryophytes and pteridophytes are much attenuated in form and lack the

pigment spot and chromatophore. Those of the bryophytes and the Lycopodineæ are biciliate while other pteridophytes have multiceliate sperms the cilia being distributed on a band (blepharoplast) which lies along one side of the spiral structure. A large portion of the spiral in these sperms is composed of nuclear substance and much of the remaining cytoplasm with granules and vacuolar inclusions may frequently be found in a vesicle attached to the larger end of the spiral.

The only motile sperm among the Fungi is that of Monoblepharis. The male cells of other Fungi are non-motile bodies (spermatia) generally formed from the ends of delicate filaments which are found in special organs called spermagonia. Spermagonia have been described in the Uredinales, the lichens and in the Laboulbeniaceæ but their function is only clearly established for the last two groups. They are very highly differentiated in the Laboulbeniaceæ and comprise several types of structure. Another type of male cell, found in certain groups of the Phycomycetes and Ascomycetes, is the cœnogamete (to be described presently) which is however not the homologue of the sperm but of the mother-cell or antheridium that develops such structures. Sperms of the red Algæ (Rhodophyceæ) are likewise non-motile and they are invariably formed singly in small cells at the ends of filaments. These non motile sperms of Fungi and red Algæ are exceedingly small uninucleate bodies without further complexity of structure as far as is known.

We shall not attempt to discuss the earlier literature that treats of the structure and development of the plant sperm. In 1894 Belajeff published a German translation of a paper written two years before in Russian which presents the views of previous investigators and to this the reader is referred for such historical references. At that time various opinions were held respecting the organization of the sperm, some writers (Campbell, Guignard and others) believing that it was chiefly or wholly nuclear in origin, while another group (Zacharias, '87, Belajeff, Strasburger, '92, etc.) thought that the cytoplasm shared very largely in its structure. Belajeff ('94a) from studies among the Characeæ showed with especial clearness that the cytoplasm was an important constituent of this sperm since the nuclear

material occupied a restricted region in the middle of the spiral structure. This was the first of a series of investigations which have given especial attention to cytoplasmic activities during spermatogenesis and placed the entire subject in a new light.

The year 1897 brought forth almost simultaneously three short papers by Webber ('97a, '97b, '97c) and Belajeff ('97a, '97b, '97c) respectively. Webber had studied the development of the motile sperms of Zamia and Ginko, Belajeff certain forms of the Filicineæ and Equisetineæ. These were of the nature of preliminary announcements and both authors published later more detailed descriptions and discussions. The discoveries of motile sperms in Ginko by Hirase and of Cycas by Ikeno were announced in several short papers during the years 1896 and '97 but without descriptions of their development. This literature together with later papers of Ikeno, Shaw, Belajeff, Hirase, and Fujii is reviewed in Webber's last contribution (:01) and also in Strasburger's discussion of "Cilienbildner" (:00, p. 177) to which the reader is referred for the most complete treatments of spermatogenesis in plants yet published.

The cycads and Ginko are the most favorable subjects known for studies in spermatogenesis. Detailed accounts of the cycads are given by Ikeno ('98b) for Cycas and by Webber (:01) for Zamia, these forms agreeing with one another in all essentials. Two sperms are developed from the daughter cells (spermatids) following the division of the so-called body cell in the pollen tube. The process really begins in the body cell with the appearance of the blepharoplasts. Their development has been followed with especial attention in Zamia. They are formed *de novo* in the cytoplasm at some distance from the nucleus and while the latter is in the resting condition. They appear independently of one another, generally on opposite sides of the nucleus but sometimes much nearer together (Fig. 10 *a*). Each is a large deeply staining body with numerous radiations extending into the cytoplasm. The blepharoplasts then increase in size and, moving farther away from the nucleus, take positions exactly opposite to one another. The nucleus of the body cell now divides, its spindle being clearly intranuclear (Fig. 5 *d*) and consequently holding no visible relation to the blepharoplasts

which lie at a considerable distance from the structure (Fig. 10 *b*). The latter cannot then be said to occupy the position of centrosomes in relation to this spindle. Meanwhile important changes, which are best known for Zamia, take place in the blepharoplast. In this type the structure forms a hollow sphere which breaks up into segments and finally into granules as mitosis proceeds. The radiations disappear without holding any apparent relation to the spindle. During telophase each of the two blepharoplasts

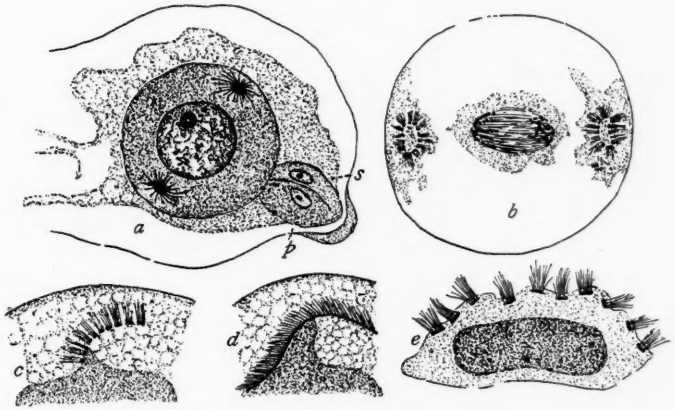


FIG. 10.—Spermatogenesis in Cycas. *a*, Body cell in pollen tube with two blepharoplasts; *s*, stalk cell; *p*, prothallial cell; *b*, anaphase of mitosis in the body cell the spindle lying between the two blepharoplasts which have begun to form cilia; *c*, Blepharoplast elongating, in contact with a process from the nucleus; *d*, end of blepharoplast attached to the nucleus at a later stage of development; *e*, sperm showing section of the flattened spiral blepharoplast with cilia projecting beyond the cell. (After Ikeno, '98.)

appears as a mass of granules at some distance from the daughter nuclei which are to become the sperm nuclei. As a result of this division the spermatids (sperm mother-cells) are differentiated. At the close of the mitosis the blepharoplast enters upon its functions of forming in the spermatid a cilia bearing band which is to lie as a spiral around the sperm. The granules first extend as a delicate deeply stained line towards the nucleus and then in the opposite direction. The nucleus in Cycas puts forth a papilla (Fig. 10 *c*) which meets this line of granules and remains attached to it for some time. The line thickens into a

band which lengthens and finally takes the form of a spiral of five or six turns which becomes more or less closely applied to the plasma membrane (Fig. 10 *e*, blepharoplast in section). The cilia develop as protuberances from the outer surface of the band (Fig. 10 *c* and *d*) and grow through the plasma membrane to the exterior of the cell. The nucleus in the meantime has increased in size until it occupies the greater part of the top shaped sperm (Fig. 10 *e*).

The history of spermatogenesis in Ginko is strikingly parallel to that of the cycads. The chief features were first described by Webber ('97c) and in greater detail by Hirase ('98). The two blepharoplasts appear *de novo* on opposite sides of the nucleus in the body cell. They show the same high state of differentiation as those of the cycads, being large and the center of a number of prominent radiations. Ginko however presents a peculiarity not reported in the previous group. A large spherical body lies between each blepharoplast and the nucleus in an area of granular cytoplasm. This structure stains deeply like the globules of nucleolar substance which are frequently found in the cytoplasm after nuclear division. They are probably accumulations of a somewhat similar material at these points in the cell to be utilized at later periods of spermatogenesis, since they decrease in size as the sperms mature. The spindle in the body cell is formed between the blepharoplasts but its poles lie at some distance from and are entirely independent of these structures. During this mitosis the spherical bodies pass to one side of the spindle so that the daughter nuclei (sperm nuclei) finally take the position formerly occupied by them. The blepharoplast becomes granular and begins to lengthen into a band, one end of which becomes attached to the nucleus that puts forth a small papilla towards the blepharoplast. The band elongates and takes the form of a spiral which makes several turns around one end of the cell just under the plasma membrane. Cilia then develop along this band as in the cycads. The earlier accounts, describing a short tail on the sperm were founded upon material that was not altogether normal and have been corrected by Webber and Fujii. The mature sperms have essentially the same form as those of Zamia and Cycas.

There has been some discussion on the morphology of these motile sperms of the gymnosperms. The claim has been made that they are ciliated spermatids (sperm mother-cells) and therefore different from the sperms of pteridophytes which are formed inside of mother-cells that upon their escape are left behind as empty cysts. However a close analysis of their structure will show that the sperms in both groups have an identical protoplasmic organization. There is a nucleus and a greater or less amount of cytoplasm in which the blepharoplast lies and the entire structure is surrounded by a plasma membrane. Any differences in the processes of spermatogenesis can only concern the greater or less development of a cellulose membrane around the spermatids. It may be true that this cellulose membrane is entirely absent in Cycas and Zamia, but if present it would be merely a shell like envelope around the sperm and cannot affect its morphological unity and agreement with the sperms of pteridophytes. A comparative study of the composition and formation of the walls enclosing sperm nuclei in the spermatophytes is much needed to carefully distinguish between plasma membranes and the cellulose secretions that may be developed by them.

While the cycads and Ginko have very much the largest sperms known and are consequently extremely favorable for an examination of spermatogenesis nevertheless some surprisingly detailed studies have been made among the Filicineæ and Equisetineæ. Following his preliminary announcements ('97a, '97b, '97c), Belajeff published in '98 an account of spermatogenesis in Gymnogramme and Equisetum. These forms present histories parallel to each other and to the cycads. Two deeply staining bodies (blepharoplasts) appear on opposite sides of each nucleus previous to the final mitosis in the antheridium which differentiates the spermatids. Consequently each spermatid receives a blepharoplast which lies close beside the nucleus. The blepharoplast begins to elongate and is followed by the nucleus so that both structures form two parallel bands which take a spiral form. (Illustrated in Fig. 3*h* of Section I.) The rest of the cytoplasm remains as a vesicle which comes to lie at the larger end of the sperm. The cilia of Equisetum could be traced to

definite granules in the band as it develops from the compact spherical blepharoplast.

There appeared almost simultaneously with the foregoing contribution of Belajeff a paper by Shaw ('98b) on Onoclea and Marsilia. Shaw investigated the cell divisions preceding the formation of the spermatids in Marsilia and discovered some very interesting conditions. The two blepharoplasts which are found in the mother cell of the spermatid are foreshadowed by smaller bodies which appear at the poles of the spindle in the two previous mitoses. The first of these structures was called a blepharoplastoid. The blepharoplastoid first appears besides the daughter nucleus after the third mitosis previous to the differentiation of the spermatids. There is therefore one for each nucleus of the grandmother cell of the spermatid. This blepharoplastoid divides but the halves remain close together and the pair passes to one side of the cell. With the next mitosis (the second previous to the differentiation of the spermatids) two new structures are formed at the poles of the spindle and from these the blepharoplasts arise. They accompany each daughter nucleus after this mitosis into the mother-cell of the spermatid. Then each divides and the two blepharoplasts pass to opposite sides of the nucleus which prepares for the final mitosis of the series. This division gives a daughter nucleus to each blepharoplast and the spermatid is thus organized. The later history of the spermatid as it changes into the sperm is identical with Belajeff's results.

Belajeff ('99) followed Shaw's account of Marsilia with a study of the same form and came to very different conclusions which have to do chiefly with his belief that the blepharoplast is a centrosome, a view that will presently be considered in connection with the opinions of Strasburger and others. Belajeff found centrosome like bodies (blepharoplastoids of Shaw) at the poles of spindles in various mitoses preceding the formation of the spermatids with their unquestioned blepharoplasts. He is not willing to concede that these centrosome like structures pass into the cytoplasm to disappear there as Shaw states for the blepharoplastoids. He also found the blepharoplasts at the poles of the spindles, which was not observed by Shaw, and holds that they have a part in spindle formation.

We are now prepared to take a general survey of the processes of spermatogenesis to harmonize as much as possible the conflicting opinions respecting the homologies of the blepharoplast. Strasburger (:00, pp. 177–215) has critically reviewed the subject and his conclusions are of great interest. He emphasizes the kinoplasmic character of the blepharoplast, whether it be a differentiated region of the plasma membrane (as he believes for the zoöspores of Cladophora, Œdogonium, etc.) or a special development in the interior of the cytoplasm (pteridophytes and gymnosperms). Strasburger thinks that all kinoplasmic structures, be they centrospheres, centrosomes or blepharoplasts, hold a very close physiological relation to the substance of the nucleolus and that their appearance and size is largely the result of nuclear activities. Accordingly the blepharoplast might occupy the position of a centrosome without being genetically related to that structure, and in fact centrosomes or centrospheres are to be considered more as products of the cells' activities than as self perpetuating permanent organs. There is abundant evidence that the last possibility is the fact in many forms both plants and animals. Since centrosomes are not found at other periods of the life history of gymnosperms and pteridophytes, Strasburger concludes that the blepharoplasts cannot be genetically related (homologous) with such a structure.

Ikeno and Hirase from their earliest writings have considered the blepharoplast to be a centrosome. Ikenó ('98a) held that the blepharoplast corresponded with the middle piece of the animal spermatozoön. Hirase ('94 and '97) although noting for Ginko that the blepharoplasts did not divide and took no part in spindle formation nevertheless called them attractive spheres. The conclusions of Shaw ('98) and Belajeff ('99) for the same type (Marsilia) have just been summarized and present very different points of view. Belajeff believes that the blepharoplast of Marsilia holds the same relation to the poles of the spindles as a centrosome. But Belajeff's conception of the centrosome ('99, p. 204) is that of a morphological and dynamic center which may or may not be easily demonstrated according to the amount of stainable substance present. From these discussions it is

evident that final judgment cannot be passed until certain questions of fact are established by reinvestigations. Shaw and Belajeff cannot both be wholly correct in their observations and interpretations and much depends upon the exactness of future studies upon Marsilia, other pteridophytes, and in the bryophytes. The problems are also related to the processes of zoöspore formation among the thallophytes.

With respect to the bryophytes Ikeno (:03) has recently published an account of spermatogenesis in *Marchantia polymorpha*. He reports for the mitoses in the antheridium, preliminary to the differentiation of the sperm mother-cells, that a centrosome appears at the side of each nucleus and divides, the two daughter bodies passing to opposite sides of the nucleus and becoming the poles of the spindle. He gives evidence that the daughter centrosomes sometimes divide again when at the poles of the spindle in anaphase. The centrosome cannot be found at the side of the daughter nucleus after the mitosis is completed but it appears when the nucleus is ready for the next division. Ikeno's explanation of the reappearance of the centrosome is unusual. He believes that the centrosome is formed within the interior of each nucleus as a deeply staining body among the linin threads. This body moves to the nuclear membrane and is thrust out into the cytoplasm through a protuberance from the nucleus. It then lies outside of the nucleus and becomes the functioning centrosome, dividing to form two centrosomes that separate to preside over the poles of the spindle. After the final mitoses in the spermatogeneous tissue the centrosomes remain to become the blepharoplasts of the sperms. Each blepharoplast passes to the plasma membrane of its sperm cell and develops two cilia. There is formed at this time another deeply staining body in the cytoplasm considered by Ikeno equivalent to a "Nebenkörper." The nucleus begins to elongate and the "Nebenkörper" takes a position between it and the blepharoplast and in this manner the much attenuated sperm is organized from the mother-cell.

Ikeno considers the blepharoplast of Marchantia to be actually a centrosome as shown by its behavior during mitosis. His account therefore in the main supports Belajeff's interpretation

of the blepharoplastoids of Shaw which as just described are regarded by the latter author as centrosomes. Both Belajeff and Ikeno are inclined to use the term centrosome with a looseness that is unusual since the first accounts of this structure gave to it a place in the cell which is not strictly followed in these authors' descriptions of spermatogenesis. Ikeno's account of the intranuclear origin of the centrosome is extraordinary. Intranuclear centrosomes have been reported in several animal forms but they do not leave the nucleus in the manner described by Ikeno.

On the whole the writer is more in sympathy with the views of Webber (:01, pp. 70 to 81), Strasburger and Shaw than those of the other authors. Assuming that the observations upon the cycads and Ginko are correct, Webber is certainly justified in emphasizing the striking fact that the blepharoplasts are completely independent of the spindle in the body cell and that they are formed *de novo* at a distance from its nucleus. These are peculiarities which, if established generally throughout spermatogenesis in plants, will remove the processes entirely from the activities of centrosomes in certain thallophytes (*e. g.* Stypocaulon, Dictyota) and in many animal cells. It is certainly to be expected that a centrosome when present will always hold an intimate relation to spindle formation during mitosis. It need not be a permanent organ in cell genesis and an ever increasing number of investigations indicate that it frequently is not. Therefore many authors hold that the centrosome is rather the morphological expression of a dynamic center than a protoplasmic structure with an individuality comparable to the organs of a cell. But these universal characteristics of centrosomes are apparently not present in the blepharoplasts of the gymnosperms nor, according to Shaw, in the pteridophytes (Marsilia). But then the observations of Belajeff and Ikeno are not in accord with those of Shaw and it is possible that studies in zoöspore formation and gametogenesis among the thallophytes may present the subject in new lights.

For as shown in our discussion of the zoöspore it is not clear whether the blepharoplasts in those cells are always derived in the same manner. We have Strasburger's view that the

structures are thickenings of the outer plasma membrane (hautschicht) and opposed to this Timberlake's account for Hydrodictyon in which the blepharoplast is considered as a structure independent of the plasma membrane although lying in contact with it. It must be apparent that the results of Timberlake are in essential agreement with the events of spermatogenesis in the pteridophytes and gymnosperms while those of Strasburger introduce new elements in giving to the plasma membrane the functions of forming a blepharoplast. The process of spore formation in the ascus must also be considered in this connection for in that sporangium a centrosphere associated with each nucleus develops numerous fibrillæ that resemble so much a cluster of cilia as to suggest at once a blepharoplast-like structure, but this centrosphere of course is an important factor in spindle formation during the mitoses in the ascus. Indeed we may well ask for further studies in spermatogenesis and zoöspore formation before we can expect a solution of the problem of the blepharoplast.

Comparisons have been made between the sperms of animals and plants, and some authors (*e. g.* Wilson :00, p. 175, Belajeff '97c) consider the two cells in essential agreement as to structure and development. However these views rest on the assumption that the blepharoplast is truly the homologue of a centrosome. It seems to be established that the locomotor apparatus of the animal spermatozoön is derived chiefly from one or more centrosomes, generally with the co-operation of archoplasm (idiozome, Nebenkern) present in some form near the nucleus. It is true that in plants the locomotor apparatus is derived from kinoplasm which as we pointed out in Sections I and II corresponds closely to the archoplasm of Boveri, but this is very far from implying that structures formed by the archoplasm and kinoplasm respectively need be homologous. Indeed both archoplasm and kinoplasm are distinguished by their physiological activities rather than by their morphological manifestations which are too various to allow of close genetic relationships. Therefore it seems far from established that spermatogenesis in plants is along the same lines as in animals, especially since the weight of evidence at present indicates that the blepharoplast is not a centrosome.

There are numerous problems connected with the physiology of the sperm that bear directly upon its protoplasmic structure. Some of these will be treated in Section IV in connection with processes of fertilization. But at this time it is well to call attention to the intimate association that sometimes exists between the nucleus and blepharoplast. These structures come into actual contact in Cycas and Ginko through a process put forth from the nucleus. It should also be remembered that Timberlake and Dangeard found the blepharoplasts in the zoöspores of Hydrodictyon and in the cells of Polytoma connected with the nucleus by one or two fibers. The nuclear beak that bears the aster in the ascus suggests a similar relationship. These conditions indicate that the activities of locomotion may depend vitally upon the nucleus.

3. The Egg.

The subject of fertilization is reserved for the next section (Section IV) of this series and the present account will deal only with the structure of the unfertilized egg. As the sperm is derived from a motile gamete identical with the zoöspore, so the egg has had a similar origin. We have traced the steps in this evolutionary process among the algæ in a former paper (*Popular Science Monthly*, Feb. 1903, p. 300). The first indication of a differentiation in the sex of primitive gametes is one of size. The male gametes tend to become smaller while the female contains a greatly increased amount of cytoplasm. One of the important factors determining this differentiation is the number of nuclear divisions which take place in the cells that produce respectively eggs or sperms. There are generally a great many more mitoses in antheridia than in oögonia and consequently a given amount of protoplasm must be very much divided to provide each nucleus with its quota of cytoplasm.

The tendency of oögenesis on the contrary is to conserve the protoplasm for relatively few nuclei, provided for several eggs or for a single nucleus in a solitary egg, with the result that the egg cell is generally richly supplied with protoplasm. Such processes result in large cells with a prominent chromatophore or

numerous plastids and not infrequently a considerable amount of food material. The primitive female gametes were provided with cilia like the male, but with their increase in size came a sluggishness of movement which resulted in much shorter periods of motility on the part of these sexual cells. There are some algæ (*Ectocarpus siliculosus*, Cutleria, Aphanochæte) whose motile female gametes come to rest shortly after their escape from the oögonia and are fertilized as quiescent cells by the active sperms. These female gametes at the time of fertilization behave physiologically like eggs although their development shows a morphology identical with the sperm. When such female gametes dispense with cilia entirely they become eggs.

The absence of cilia does away with very much of the complexity which we have just described for sperms. There is no trace of the blepharoplast in the egg and no indication of the activities associated with this structure, so conspicuous in spermatogenesis. The large motile female gametes of such Algæ as Bryopsis, Cutleria, Aphanochæte and certain species of Chlamydomonas and Ectocarpus will probably show some interesting conditions when the details of their cell structure and development are known, for some of these types are likely to throw light on the relation which the blepharoplast bears to other structures in the cell.

The eggs of all plants (Fungi excepted) are believed to be richly stocked with plastids in sharp contrast to the sperms which are entirely destitute of these structures in all groups above the algæ. The plastids in the eggs of Algæ contain the pigments characteristic of the respective groups giving these cells a very rich coloration and sometimes an elaborate internal structure since these plastids or the single chromatophore generally maintain a symmetrical relation to the nucleus. Leucoplasts (see Fig. 11*a*) have been found in the eggs of angiosperms (Schimper, '85) but detailed studies on the cytoplasm of such cells in spermatophytes, pteridophytes and bryophytes are greatly to be desired to determine the history of plastids during the development of these germ cells and at later periods after fertilization.

The distribution of the plastids in the eggs of Algæ may be so general that the entire cell is colored as in Fucus, Volvox and Sphæroplea. Or, the plastids may be largely or wholly withdrawn from some portion of the egg. It is usual for eggs retained within the parent cell (oögonium) to present a colorless area of protoplasm that becomes the point at which the sperm fuses with the egg. Such a hyaline region is called the receptive spot and is generally situated (see Fig. 11*b*) at the side of the egg nearest the pore or opening in the oögonium through which the sperms enter. Excellent illustrations are presented among the Algæ in Vaucheria (Oltmanns, '95), Œdogonium (Pringsheim, '58, Klebahn, '92) and Coleochæte (Pringsheim, '60, Oltmanns, '98). It has been suggested that the receptive spot is related to the clear ciliated end of the ancestral motile gamete and zoöspore but the structures have not been critically compared to determine the precise character of their protoplasmic structure and development. The receptive spot in some forms (Vaucheria, Œdogonium, Fig. 11*b*) lies directly under the opening that is formed in the oögonium and its protoplasm is probably concerned with the fermentative action that destroys the wall at that point.

The red Algæ (Rhodophyceæ) do not have eggs although in their sexual evolution they are at the level of heterogamy. The female gamete (carpogonium with its trichogyne) is a cell homologous with an oögonium and its protoplasmic contents correspond to an egg, but the protoplast never withdraws from the cell wall to lie freely as a naked mass of protoplasm within the structure. But the general agreement of the carpogonium and trichogyne with the oögonium and its neck like extension in Coleochæte seems to determine without doubt the homologies of the former.

There are very few eggs among the fungi that are strictly comparable to those of the Algæ. Monoblepharis (Thaxter '95a) however unquestionably furnishes such an example. But the eggs of the Saprolegniales and Peronosporales are probably in the author's opinion not directly derived from those of Algæ. They are either a peculiar form of sexual cell called the cœnogamete (Davis :00 and :03) or closely related to this structure

which will be given a separate treatment in this section. The cœnogamete is the homologue of a multinucleate gametangium but its evolutionary tendencies seem to be towards such a reduction in the number of nuclei that in the highest expression of its sexual differentiation the female cell contains a single nucleus and has the general form of an egg. But this process of sexual evolution is entirely independent of the well known lines of development in the Algæ (Davis, *Popular Science Monthly*, Feb. 1903). The female sexual cell of the Ascomycetes (called the ascogonium or archicarp) is probably in most forms the homologue of a gametangium. These subjects will be treated in our account of the cœnogamete.

The egg in the archegonium of bryophytes and pteridophytes is generally reported to have a clearer region on the side nearest the neck and this is called the receptive spot. It is reported by Campbell in his investigations on Pilularia ('88), Isœtes ('91), Osmunda ('92a), Marsilia ('92b), and Marattia ('94), by Shaw in Onoclea ('98) by Thom in Aspidium and Adiantum ('99) and by Lyon in Selaginella (:01). The receptive spot is generally believed to be a portion of the egg differentiated to receive the sperm. It is an open question whether this area is morphologically the homologue of the receptive spot in the eggs of algæ and the clear area at the ciliated end of motile gametes and zoöspores. The problem demands a detailed study of the finer protoplasmic structure to determine whether or not it is kinoplasmic in character. The nucleus is generally situated near the center of the egg and the portions of the cell farthest away from the neck of the archegonium contain coarsely granulate protoplasm which is evidently trophoplasmic, *i. e.*, much of its substance is of the nature of food material and the products of metabolism. The leucoplasts would be supposed to lie in this region of the cell but we know nothing of their presence and behavior in the egg of bryophytes and pteridophytes.

The eggs of gymnosperms generally speaking present sharp contrasts to those of pteridophytes. They are very large, probably the largest uninucleate cells in the plant kingdom, and consequently very attractive for cell studies and some of the best work on the events of the maturation and fertilization of plant

eggs has been done on this group (to be treated in Section IV). Passing over earlier investigations that described accurately the general structure of the egg of gymnosperms we shall consider the results of a number of comparatively recent papers that treat especially the pine, spruce (Picea), hemlock (Tsuga), fir (Abies), cycads, Ginko, Gnetum, Taxodium, etc.

Oögenesis and fertilization in the pine has been the subject of several extensive studies the chief being papers by Dixon ('94), Blackman ('98), Chamberlain ('99) and Ferguson (:01b). The protoplasm of the egg is at first vacuolate but later takes on a denser structure which becomes very puzzling because of numer-

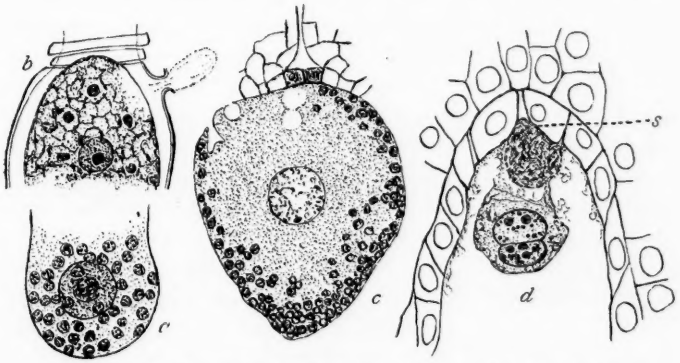


FIG. 11. — The Egg. *a*, Daphne, showing leucoplasts; *b*, oedogonium, showing receptive spot; *c*, pine, with numerous proteid vacuoles; *d*, embryo sac of the lily, gamete nuclei fusing, remains of one Synergid (*s*) shown. (*a*, after Schimper, '85; *b*, Klebahn, '92; *c*, Ferguson, :01.)

ous granular inclusions and masses of amorphous material which together with fibers present a very complex texture. The fibers are sometimes collected in fascicles and they may form a sort of weft at the periphery of the egg or radiate out from the nucleus which is generally surrounded by a kinoplasmic sheath. The complexity is greatly increased as the egg grows older by the development of remarkable structures called proteid vacuoles (See Fig. 11*c*) which have been especially described by Blackman and Ferguson. The number of proteid vacuoles is exceedingly variable in the egg but they sometimes fill three fourths of the structure. They are spaces in the cytoplasmic reticulum filled

with granules and irregular masses of a proteid nature some of which stain like nucleoli. The proteid vacuolee were considered nuclei by earlier writers (Hofmeister and Goroschankin) and recently this view has been revived by Arnold (:00b) who describes the migration of large numbers of nuclei from the cells of the jacket surrounding the egg into that structure. These results have not been confirmed by Ferguson who agrees with the interpretation of other writers that the resemblance of the proteid vacuoles to nuclei is superficial. Miss Ferguson believes that the material of the proteid vacuoles is derived in part from the nucleoli in the cells of the jacket and from those in the egg. A vacuole is reported (Ferguson) at the end of the egg nearest the neck of the archegonium and this is regarded as a sort of receptive spot since the pollen tube discharges its contents into this cavity. The egg nucleus is very large and its contents are not arranged with the regularity generally present in resting nuclei. There are numerous bodies which Chamberlain believes to be chromatic in composition that look very much like nucleoli and have been so designated by that writer. But there is generally one large unquestioned nucleolus and besides this many smaller nucleoli are reported by Ferguson as held in the linin reticulum. Then portions of the linin frequently take irregular forms and stain heavily. There is also present besides the linin, chromatin and nucleoli much granular material (metaplasm), especially in the nuclei of younger eggs, which probably holds some relation to the chromatin although it may readily be distinguished at certain times from that substance.

Recent accounts of the spruce and fir, by Miyake (:03a and :03b) describe conditions very much as in the pine. The egg of the spruce (Picea) is apparently not so fibrous in structure but proteid vacuoles give it a coarse granular structure. He finds no evidence in support of Arnoldi's (:00b) peculiar views that the proteid vacuoles are derived from nuclei that have passed into the egg from cells of the sheath. They are simply masses of nutritive material. There is some doubt whether the vacuoles present at the end of the egg really represent a differentiated receptive spot. The egg of the fir (Abies) conforms in all essentials to the structure in the pine and spruce. There are numerous proteid vacuoles.

It is probable that the eggs of other conifers will be found to present much the same protoplasmic structure and activities as those of the pine. Thus Murrill (: 00) describes for the hemlock spruce (Tsuga) a vacuolar receptive spot and figures masses of food material very much like the proteid vacuoles. The general features of the egg of Cephalotaxus (Arnoldi, : 00a), Thuja (Land, : 02), Podocarpus (Coker, : 02), Taxodium (Coker, '03) have been recently described and those of Abies, Larix and Taxus are familiar from older writers but the pine remains as the type of conifer in which the events of oögenesis are best known as regards the details of protoplasmic activities.

Besides the pine we have had some very complete investigations on cycads and Ginko (Hirase, '98, Ikeno, '98b and : 01, Webber, : 01). In some respects these types and especially the cycads seem to be the most favorable of all the gymnosperms for the study of gametes and the processes of fertilization (to be described in Section IV). The cytoplasm of the egg is comparatively homogeneous in structure so that the cell is relieved from the complicated fibrous structure and proteid vacuoles present in the pine. Ikeno ('98b) finds that the egg of Cycas develops a crater like depression just before and at the time of the fusion of the sperm thus presenting a rather highly specialized receptive spot.

We know almost nothing of the detailed structure of the egg in the Gnetales. Ephedra (Strasburger, '72) develops archegonia much like those of other gymnosperms and we should not expect their eggs to be materially different even in details. But the conditions in Tumboa (Welwitschia) are peculiar and approach more closely those of angiosperms where the egg nucleus is scarcely differentiated from neighboring nuclei lying freely in the protoplasm at one end of the embryo sac. The eggs of Tumboa (Strasburger, '72) are merely cells of the prothallus that push out small projections to meet the pollen tubes. Gnetum presents a further simplification or reduction since the female nuclei lie freely in the protoplasm at one end of the embryo sac. In *Gnetum gnemon* the lower half of the embryo sac is filled with a tissue (Lotsy '99) but in several other species studied by Karsten ('92, '93) no cell walls are found in the entire sac until after fertilization.

The angiosperms present no especial advance over Gnetum in the organization of the egg except that this structure is generally reduced to a single female nucleus and the cytoplasm immediately around it (see Fig. 11 *d*). This egg nucleus flanked by two companions (synergids) and the accompanying protoplasm compose the egg apparatus whose morphology is still a matter of dispute. It is possible that the synergids may stand for portions of a reduced archegonium, but the two nuclei bear such close relations to the egg and polar nucleus that it seems very probable that they are homologous with these structures which have clearly defined sexual potentialities. In spite of the numerous studies on embryo sacs in various groups of angiosperms we do not yet know precisely how the cytoplasm becomes gathered around the egg nucleus and the synergids. The spindles that are formed between these nuclei in some types (*e. g.*, Lilium) have been supposed to lay down walls by means of cell plates. But there are other forms in which the protoplasm seems to separate along planes of vacuoles without relation to spindle fibers.

(*To be continued.*)

NOTES AND LITERATURE.

ZOÖLOGY.

Dodge's General Zoölogy.[1] — The title on the cover and the "book notice" sent out by the publishers do not suggest that this is otherwise than an entirely *new* book, but in small type on the title page is the information that this is a "revision and rearrangement" of Orton's *Comparative Zoölogy* — a well-known text-book written in 1876 by the late Professor Orton of Vassar College and revised by Birge in 1883 and by Dodge in 1894. But even the information on the title page does not prevent the reader from expecting to find that the new author and new title mean that the book has been recast so completely that the original author deserves credit for only a minor part of the book. Careful examination leads to disappointment. Parts I and II of the original work and its revisions are interchanged, and there are two new chapters — one on practical work and the other on origin of animal species. In all other respects, the chapters, sections, and paragraphs of the greater part of the book stand essentially unchanged, except in minor verbal changes and revisions of the classification and morphology in accordance with discoveries made since the original book and its earlier revisions appeared. Thus Dodge's *General Zoölogy* is analyzed into Orton's *Comparative Zoölogy* with probably 90 per cent of the sentences essentially as Professor Orton wrote them thirty years ago, and added to this about forty pages of new material. In the light of these facts any fair-minded man of science will not hesitate to condemn the change of title and author's credit and especially the method of advertising the book as a *new* one. In all fairness to purchasers and to the principle of credit for original work, the so-called Dodge's *General Zoölogy* should hereafter be known to teachers of zoölogy as Orton's *Zoölogy* revised and extended by Dodge; and as such the chief value of the book is that of the original work with the changes made necessary by advances in zoölogical knowledge. These have been great, but in such a general text-book the majority of the revisions have been possible without rewriting the original sentences.

M. A. Bigelow.

[1] Dodge, C. W. *General Zoölogy*. New York, American Book Co. 1903. 8vo, pp. 512, 379 figs.

Coues' Key to North American Birds[1] had nominally four editions, but the third and fourth were practically reprints of the second (1884) edition. At his death, Dr. Coues was at work on a new edition, the MS. of which was fortunately completed by him. It has been published as the fifth edition of the Key under the direction of Mr. J. A. Farley, to whose conscientious care the publishers give due praise.

The present edition appears in two large volumes containing over eleven hundred pages. The Historical Preface of former editions is followed by a short memoir of the author, being the address delivered by D. G. Elliot at the A. O. U. Congress in 1900. Part I, on Field Ornithology is reprinted without change. Part II on the Structure and Classification of Birds has been somewhat revised. That Dr. Coues nailed his colors to the mast is evident from a paragraph on p. 80, where though he avows his allegiance to the A. O. U. code of nomenclature, he expressly excepts the canon which requires him to misspell a name " for no other reason than because it was misspelled in the beginning."

A less gratifying evidence of his courage in his convictions is given in the discussion of color-change without moult, or Aptosochromatism (p. 92) as Dr. Coues was proud to have termed it. It seems strange that the pages that follow could have been written after the publication of Mr. J. A. Allen's paper in the Bull. Amer. Nat. Hist. 1896.

The chief additions in this edition are in Part III, Systematic Synopsis of North American Birds. Here have been incorporated the results which the study of systematic ornithology has achieved within the last twenty years. The descriptions of many species, and of their nesting habits have been rewritten, particularly in the case of western birds. Many new species and sub-species have been accorded recognition. Such difficult groups as the Small Flycatchers (Empidonax) and the Horned Larks (Otocorys) now appear as they were left by the more conservative treatment of Brewster and Dwight. Most of the changes in nomenclature made by the A. O. U. committee have been accepted, and in some cases some of those not made at the time of Dr. Coues's death were foreseen and included. The changes made since his death appear in an appendix. There have been added to many of the biographies, especially to those of the less familiar birds, the more important synonyms and bibliographical

[1] *Key to North American Birds.* The Fifth Edition. Coues, Elliott, Boston, Dana Estes and Co. 1903. pp. 1152.

references. The accounts of the orders and families have been largely rewritten, and include references to extra-limital groups so that the relationships of North American birds to foreign groups is more clearly brought out. Most of the old illustrations have been retained, and over two hundred new ones have been prepared for this edition by Fuertes. Old admirers of the Key will probably rejoice to see the old familiar cuts, absurdly inadequate or useless as many of them were, and now cruelly contrasted with Fuertes' brilliant work.

The great influence which Coues' Key exercised on the ornithologists of the past generation is well known, and it is gratifying to see his work brought as nearly as possible up to date, and its capacity for usefulness thus prolonged. It was always a bulky book, and now, in its present form, it cannot serve as a manual; it must yield the field to later excellent "Keys." But it may still rank as one of the most valuable works on the reference shelf, especially to those who grew up with it.

One is curious, however, with regard to this work of Fuertes, to know whether it represents that artist's earlier or later style. In some of it his worst faults in bird portraiture are too prominent. In his drawing of the Mountain Chickadee (p. 271) in his efforts to show the plumpness of a vigorous bird, the artist has given us an absurd little caricature.

R. H.

Boulenger on the Classification of Bony Fishes.—The most important recent contribution to the taxonomy of fishes is "A Synopsis of the Suborders and Families of Teleostean Fishes," by Dr. G. A. Boulenger of the British Museum, published in the *Annals and Magazine of Natural History* for March, 1904. It is based on his own studies of the fish skeletons in the British Museum and on the work of Woodward, Gill, Jordan, Starks and Regan. The special effort has been to show the relation of the different members of this great group of nearly 12,000 species by a classification based on our knowledge of phylogeny. The result of Dr. Boulenger's work is not essentially different in fact from that of Dr. Gill, although there is considerable divergence in nomenclature. Dr. Gill has preferred to isolate aberrant groups until their true relationship is known. As a result he has recognized twice as many families and twice as many orders as Boulenger, many of these families and orders being provisional. The advantage of this method lies in clear definition. The

result of leaving aberrant forms in the group nearest to them is to destroy all possibility of exact limitation. It is at the best impossible to frame exact definitions when transitional groups of all grades exist. A few orders can be isolated and defined among the bony fishes, but the group as a whole cannot be divided into orders or suborders or any other categories which shall have even approximately equal value.

There is no sharp line separating the Isospondyli or Salmon-herring series from the Ganoids, from which they are derived. From the Isospondyli or Malacopterygii, as Dr. Boulenger calls them, all other bony fishes seem to be descended. But the line between the Isospondyli and the Haplomi is a narrow one. The Haplomi have lost the mesocoracoid bone, and as it is abortive in many species (Synodontidae, Myctophidæ) hitherto attached to the Isospondyli, these are placed by Boulenger among the Haplomi. Among the Haplomi, on the other hand, are placed the spiny-rayed Percopsidæ because these have not lost the air duct characteristic of the Isospondyli and their allies.

The eels are divided into two suborders, —the Ostariophysi remain together as one. The Heteromi are made to include Dercetidæ, Halosauridæ and Fierasferidæ.

The transitional types with abdominal ventrals, the air duct and the mesocoracoid being lost, constitute two suborders, which do not differ from each other in definition although comprising different categories of families. The first of these is the suborder of Catosteomi, comprising the Selenichthyes (Lampris), the Hemibranchii, the Lophobranchii, and the Hypostomides. The present reviewer sees no reason for associating Lampris with this group. Its suborder (Selenichthyes) is worthy of independent recognition. The others certainly belong together, and almost as certainly are degenerate or specialized allies of the other transitional group of Percesoces.

In Boulenger's scheme, the Percesoces include not only the Atherinidæ-Sphyrænidæ-Mugilidæ series, but also the Scombresocidæ, the Polynemidæ, the Chiasmodontidæ, the Tetragonuridæ, the Stromateidæ, the Ophiocephalidæ, and the Anabantidæ. As thus arranged, the group is defined only by the imperfect attachment of the ventral fins to the thoracic arch. It cannot be exactly defined and its members are very divergent. It is fair to say, however, that the fault lies with the fishes, not with the classifier. The transitional elements between soft-rayed and spiny-rayed fishes are all still extant, and their intergradations defy classification. For this reason, Dr. Gill once

proposed the name Teleocephali for the order containing the whole ancestral trunk of the bony fishes, from the primitive semi-ganoid types to the highly specialized cottoids and labroids, leaving only the divergent branches to be recognized as separate orders.

The Anacanthini, relieved of the flounders which have no relationship to the cod-fishes, Dr. Boulenger places near the Persesoces.

The Ammodytidae are wrongly placed by Dr. Boulenger with the Percesoces; as in Embolichthys, the genus possessing ventral fins, has these fins at the throat.

The great body of the remaining fishes are placed in the suborder Acanthopterygii, defined essentially as by Gill, Jordan and Evermann and Hay. The Beryces are placed among the Perciformes. The recent discovery by Mr. Starks that all Beryces possess the orbitosphenoid bone, absent in other Acanthopterygii and characteristic of the lower forms, indicates that the Beryciformes (Pempheris and Aphredoderus excluded) should form a division by themselves.

The group Zeorhombi, containing Zeidæ and the flounders, represents an ingenious guess. Even if the flounders, as is probable, be descended from ancestors of Zeus, the present differences justify their separation into a distinct division. Zeorhombi is insusceptible of definition. The remaining orders, Opisthomi, Pediculati, Plectognathi, are arranged as generally accepted, but the Plectognathi are only specialized and degraded offshoots from the Chætodontidæ–Acanthuridæ series with which they form a nearly continuous line of degeneration.

As Dr. Boulenger extends the range of his work, he will find it convenient to recognize a greater number of families, while American ichthyologists will mark their progress by the gradual reduction of the number defined by them. This arises from a different method of work, a different view as to convenience in regard to divergent or imperfectly known forms. Thus every year brings workers on the taxonomy of fishes nearer and nearer together, and farther and farther from the Cuviernian idea of the perch as a perfect fish to be placed first with the others following after.

D. S. J.

Notes on Recent Fish Literature.— In the *Bulletin U. S. Fish Commission* (1902) Jordan and Evermann describe two new fishes from Hawaii, *Tropidichthys psegma* and *Iracundus signifer*, the latter representing a new genus of Scorpænidæ, allied to Pontinus.

In the *Bulletin of the U. S. Fish Commission* for 1902 (1903),

William C. Kendall gives a useful list of the certain river-fishes of Maine. *Leuciscus carletoni*, a new species, with a barbel, and therefore better referred to Couesius, is described as also *Pimephales anuli* (named for Edgar E. Ring) and *Coregonus stanleyi*.

In the *Revista Chilena de Historia Natural* (Valparaiso, VII, 1903) Dr. F. T. Delfin discusses in much detail the fishes known as Congrios in Chile, Ophidiidæ of the genus Genypterus.

In the *Smithsonian Miscellaneous Collections* (XLV, 1903), Dr. C. H. Eigenmann defines 21 new genera of South American river fishes of the group of Characinidæ in advance of his monographic review of the group. It is to be regretted that a closer adherence to classical models did not prevent the suggestion of such names as Holosthesthes, Stichonodon, Colossoma and Mylossoma.

In the *Proceedings of the Zoological Society* of London (1903), Mr. C. T. Regan gives a review of the East Indian fishes of the genus Triacanthus. In this as in many other cases it appears that the species recognized by Dr. Bleeker are all really valid in spite of the doubts expressed by subsequent authors with more scanty material.

In the *Proc. U. S. Nat. Museum* (XXVI), Barton A. Bean describes a new minnow, *Notropis brimleyi* (near *N. coccogenis*) from Cane River, North Carolina.

In the *Atti della Società Italiana di Scienze Naturali* (XLII, 1903), Dr. Cristoforo Bellotti of the Museum of Milan describes an interesting new species of fish, *Pteraclis macropus*, taken off Yokohama.

In the *Proceedings of the U. S. National Museum* (XXVII, 1904), Mr. E. C. Starks discusses the osteology of the berycoid fishes. This group is one of especial interest because it appears earlier in geological time than any other of the distinctly spiny-rayed types, and it is probable that all these are described from Berycoid stock.

Dr. Boulenger unites the berycoids with his perciformes, notwithstanding the archaic characters retained by most of them. Mr. Starks shows that all of them retain one hitherto unnoticed archaic character which is lost in all the other spiny-rayed fishes. This is the development of the bone called osbitosphenoid.

This bone he finds in Hoplostethus, Beryx, Holocentrus, Myripristis, Polymixia and Monocentris. It is not found in Pempheris or in Aphredoderus, which genera should be excluded from berycoid association. The orbitosphenoid is present in the Isospondyli and in the ganoids. It is wanting in the Haplomi and in Aulopus and

Synodus. This fact may indicate an additional character by which to distinguish the order Haplomi, and that Boulenger is right in referring Aulopus and Synodus to this order.

Starks finds that the close resemblance of the barbels in Polymixia to those in Mullus and Upeneus has no phylogenetic significance. While the organs in the two cases look much alike, they are developed in quite different fashion.

In Polymixia each barbel is suspended from the hypohyal, where three short, rudimentary branchiostegals curve around its thickened base. In Mullus and its relatives, the barbel is the extreme tip of a slender ray of bone attached to the end of the ceratohyal, and without relation to the branchiostegals.

In the *Bulletin of the U. S. Fish Commission* (1902, published 1904), Professor John O. Snyder gives a list of the shore fishes taken by the "Albatross" expedition in 1902. Two hundred and twenty-seven species are recorded, with excellent figures of 25 new species not taken by the previous expeditions of Dr. O. P. Jenkins (1889) and Jordan and Evermann (1901). Two new genera are described, Veternio, a toothless Conger eel, and Collybus, a genus of Bramidæ.

In the *Bulletin U. S. Fish Commission* (for 1902, published in 1904), Dr. Jordan gives a list of species of small fishes from coral pools, taken at the Tortugas, Florida, by Dr. Joseph C. Thompson, U. S. N., now surgeon of the "Albatross,"—*Ctenogobius tortugæ*, *Gnatholepis thompsoni*, *Elacatinus oceanops*, and *Ericteis kalisherœ*. Elacatinus is a new genus of gobies, Ericteis a new genus of blennies, in which group another genus, *Acteis* (*moorei*), is detached from Malacoctenus.

Chaetodon bricei is shown to be the young of *Chætodon capistratus*, and the nominal species of Doratonatus are all probably identical with *D. megalepis*. The rare *Holocentrus siccifer* (Cope 1871) is again recorded.

Mr. Henry W. Fowler, now of the Academy of Natural Sciences at Philadelphia, has in the *Proceedings* of that institution (1903) a number of papers on fishes largely of the Pacific Ocean. Of special interest are the following: *Atherina sardinella*, a new species from Italy; Atherinomorus, a new sub-genus for the West Indian *Atherina laticeps*, *Protistius semotilus* Cope redescribed. This genus is allied to Atherinopsis, but has only a single dorsal spine. Gastropterus Cope is the same as the later Pisciregia of Abbott.

Atherinops magdalenæ Fowler is described from Magdalena Bay, Lower California. *Mugil kelaarti* is described from Honolulu. *Liza caldwelli* is redescribed from Samoa. A new sub-genus, Aodalechilus, is proposed for *Mugil labeo*. *Sphyræna tome* is described from Sambaia, Brazil. *Centrobranchus chærocephalus* is described from Hawaii. Centrobranchus is a new genus of Myctophidæ allied to Rhinoscopelus, but the gill rakers reduced to bunches of spines.

Numerous species are recorded from Zanzibar. These papers are illustrated with good plates.

In the Danish *Meddelser om Grönland* (XIX, 1904), Mr. A. S. Jensen gives a list of the fishes of Eastern Greenland, based on the collections of the Amdrup-Hartz expedition of 1900. Thirty-six species are included, the following being new: *Lycodes eudipleurostictus*, *Lycodes* (*reticulatus*) *macrocephalus* and *Lycenchelys kolthoffi*. Excellent faunal notes are given with a very convenient bibliography. According to Jensen, the American Cottus or *Oncocottus hexacornis* is identical with the European *quadricornis*, as Jordan and Evermann had suspected. The American *Artediellus atlanticus* is also shown to be the same as the European *A. uncinatus*, from which Jordan and Evermann thought it apparently distinct. The name *Icelus bicornis* is rightly used instead of the later *Icelus hamatus*. The Greenland species known as *Liparis tunicata* proves to be the same as *Liparis liparis*. *Liparis fabricii* is different. *Paralepis kröyeri* is shown to be different from *P. borealis* and the Charr of East Greenland is identified as *Salmo* (better *Salvelinus*) *alpinus*. The engravings are entirely worthy of this admirable piece of faunal study.

Professor Keinosuke Otaki of the Imperial Military Academy of Tokyo, a graduate of Stanford University, has begun in connection with Professor T. Fujita and T. Higurashi the publication of a serial work entitled "Fishes of Japan." The text is in Japanese and English. The species included in part first are *Lateolabrax japonicus*, *Latilus sinensis*, *Gymnosarda affinis* and *Seriola quinqueradiata*. These are illustrated by colored plates well executed by Mr. K. Ito.

In the Report on the Sea and Inland Fishes of Ireland for 1901, Messrs. E. W. L. Holt and L. W. Bryne describe and figure a translucent symmetrical larval flounder, which they regard as the young of the "White Sole," *Glyptocephalus cynoglossus*. The mouth is shown as much larger than in the adult of this species, which may throw doubt on the identification.

The same gentlemen in a later paper describe and figure all the British gobies. Their plates will greatly aid in the identification of these little fishes.

In the *Annuaire du Musèe Zoologique* at St. Petersburg (VIII, 1903), L. S. Berg discusses a collection of Cottoid fishes from Lake Baical, with observations — unfortunately in Russian — on the classification adapted by Jordan, Evermann and Starks. Two new genera, *Baicalocottus* and *Batrachocottus*, are defined, with the genus Procottus of Gratz.

When the present writer was in Japan in 1900, the Imperial Museum generously placed at his disposal all duplicates of new species of fishes contained in the Museum. Those represented by single examples could not be sent away, and these the director of the Department of Natural History, Dr. Chiyomatsu Ishikawa, has undertaken to describe for the sake of completing the rich faunal list of Japan.

In the *Proceedings of the Imperial Museum*, Dr. Ishikawa describes the following new species, most of them with good figures:

Zezera hilgendorfi, Zacco mitsukurii, Leuciscus dorobaë, Stromateoides nozawæ, Heterognathodon dœderleini, Cirrhilabrus lyukyuensis, Amphiprion snyderi, Crenilabrus stejnegeri, Tetraroge kagoshimensis, Hemitripterus nipponicus, Podothecus tokubire.

Of these the Crenilabrus from the Riu Kiu Islands is the most interesting, as that genus, largely represented in the Mediterranean, had never before been recorded in other waters. The Tetraroge should rather be referred to the genus Erisphex.

In the *Records of the Australian Museum* (V, 1904) Mr. Edgar R. Waite gives an account of his explorations of Lord Howe Island. Seventeen known species of fishes were added to the fauna of this interesting island. Ten new species were discovered, most of these with a number of other interesting forms being figured by Mr. Waite. The new genera are Xenogramma (Gempylidæ), Allogobius, Limnichthys (Trichonotidæ) and Lepadichthys (Gobiesocidæ). The fauna as a whole, although distinctly tropical, is very different from that of Hawaii or Samoa.

In the same *Records* (V, 1904) Mr. Waite gives a list of the fishes known from Lord Howe Island, 180 in number, with a bibliography. The list is especially useful for comparison with faunal lists of the South Seas, the genera being largely identical, the species different. In this list Mr. Waite has taken special care to verify the dates of publications.

In the *Transactions of the American Philosophical Society* (XX, 1901) Dr. O. P. Hay gives a valuable table showing the chronological distribution of the genera of elasmobranchs. He calls attention to one remarkable fact. While many genera and species (Cladoselachidæ, Acanthoëssidæ, Psammodontidæ, Pleuracanthidæ, Cladodontidæ, etc.) occur in the Devonian and Carboniferous ages, only three genera remain in the Permian and but four in the Triassic. All these are Heterodontidæ, the successors or descendants of the Orodontidæ of the Carboniferous. In the Jurassic, numerous families with many genera appear, and through these from Heterodontid stock the modern sharks seem to have sprung. Apparently the Paleozoic families, except the Orodontidæ, have no modern descendants.

In the *Bulletin of the Museum of Comparative Zoölogy* (XLI, 1904) Samuel Garman gives an elaborate and excellent account with beautiful plates of the anatomy of the long-nosed Chimæra of Japan, *Rhinochimæra pacifica* (Mitsukuri). In connection with the study of this species, he has given a general account of the living chimæroid fishes, with figures of some of them. On grounds of priority, Mr. Garman substitutes the name Chismopnea Rafinesque, 1815, for the later name Holocephala of Muller (1834).

In the *Geological Magazine* (IX, 1902) Dr. Charles R. Eastman founds a new family of fossil sharks, Peripristidæ, on the genus Peripristis (Pristodus).

In the *American Geologist* (XXX, 1902) Dr. Bashford Dean gives illustration of a startlingly perfect preservation of the muscular fibre of a shark, *Cladoselache fyleri*, in the Cleveland shales. This was an estuary deposit originally of fine mud, in which the fish remains became phosphatized.

In the *Proceedings of the Academy of Natural Sciences of Philadelphia* (1903) Dr. Carl H. Eigenmann and Clarence H. Kennedy discuss a large collection of river fishes, made in Paraguay by Prof. J. D. Anisits of the Paraguay National University. One hundred and nine species are noted, many of them new, and the paper is followed by a useful biography. A feature of special convenience is a synopsis of the genera of Cichlidæ, 25 in number, Biotodoma and Biotœcus being new names.

In the *Annotationes Zoologicæ Japonenses* of the Imperial University of Tokyo Dr. Bashford Dean gives a study of the development of the egg of the Japanese shark, *Heterodontus japonicus*. He finds good evidence of the existence of holoblastic cleavage.

In the Christiana *Videnskabs-Selskabs Vorkandlinger* for 1902 and 1903 (the last volume being published from the Fridtjof Nansen fund) Dr. Robert Collett gives additional records of additions to the fish fauna of Norway. These admirable notes are of great value to the student of the fishes of Northern Europe, as well as of Northern regions generally.

Jordan and Starks continue in the *Proceedings of the U. S. National Museum* (XXVII, 1904) their monographic accounts of the fishes of Japan.

In the review of the Scorpænidæ 52 species are described as Japanese, 14 of these being new. These are arranged in 23 genera, the following being new: Thysanichthys, Sebastiscus, Lythrichthys, Ebosia, Decterias, Inimicus, Ocosia, Erisphex. The new species and most of the new genera are figured.

The Cottidæ of Japan are also described in detail by the same authors. In these fishes as in the Scorpænidæ, of which the Cottidæ are the Arctic descendants, the waters are particularly rich. Fifty-seven species are described, 19 being new. These are arranged in 40 genera, the new genera being Stlengis, Schmidtia, later called Schmidtina, the name Schmidtia being preoccupied. Daruma, Ricuzenius, Rheopresbe, Ainocottus, Crossias, Elaphichthys, Alcichthys, Furcina, Ocynectes, Bero, Vellitor.

Similar reviews cover the less numerous species of the families of Agonidæ and Hexagrammidæ.

The two species of white Chimæra (*Chimæra phantasma* and *Chimæra mitsukurii*) found in Japanese waters are described and figured by Jordan and Snyder.

D. S. J.

PALÆONTOLOGY.

Eastman's Translation of Zittel, Vol. II.[1]—Since the publication of the first volume of Dr. Eastman's translation of Zittel's *Grundzüge der Palæontologie*, English speaking students have awaited with keen interest the appearance of the second volume, and it may

[1] von Zittel, Karl A. *Text-Book of Palæontology*, Vol. II. Translated and edited by Charles R. Eastman. London and New York, Macmillan, 1902. 8vo, 283 pp., 373 figs.

be said that the latter fully maintains the high standard set in the earlier portion of the work. The present volume treats of the Vertebrates, with the exception of the mammalia, to the consideration of which class the third and last volume will be devoted.

The general method of treatment which has made Zittel's works so valuable to the student happily has been closely adhered to in the translation; we refer especially to the introductory sections on the various classes, and to the brief diagnosis in italics with which the consideration of each group,— class, sub-class, order and family, — is introduced. It is largely to this latter feature that these works owe their superiority as books for ready reference.

In comparing the English edition with the original we note first very considerable amplification and revision, representing the advance in Palæozoölogy during the seven years since the publication of the earlier work, and in this enlargement and revision Dr. Eastman has had the collaboration not only of the author but of a number of competent English and American specialists. As regards Taxonomy the changes from the original have been very slight, far less indeed than we had hoped to see, and it is to be regretted that the editor and his collaborators so far subordinated their own views on classification to those of the author, since some rearrangement, especially of the fishes and reptiles, was quite desirable.

The entire section on fishes has been translated and revised by Dr. Arthur Smith Woodward of the British Museum. Dr. Woodward has been rather conservative in the matter of revision and has kept his own opinions on taxonomic points very much in the background. Of this section the part on ostracoderms has undergone the most extensive revision, chiefly based on the recent researches of Traquair. Thus we find Traquair's order Anaspida included, and in all nine families of ostracoderms are recognized. The Arthrodira, which in the original were given ordinal rank among ostracoderms, are now very properly placed as a sub-class, but the Macropetalichthyds — the Anarthrodira of Dean — are ranked *incertæ sedis*. It is rather to be regretted that the old division of the bony fishes into Ganoidei and Teleostei has been adhered to, instead of the better morphological differentiation of Crossopterygia and Actinopterygia. The old system has, however, the merit of familiarity and convenience. The section on ganoids has been amplified about one half and has been thoroughly revised. Little is said regarding the systematic position of the Dipnoi, but we can scarcely approve of their place in the book, in immediate sequence to the Arthrodires; it suggests tacitly the former supposed relationship of the two groups.

The section on Amphibia, revised by Dr. E. C. Case, differs but little from the original, except in the added descriptions of several genera. The taxonomic system is unaltered and, on the whole, is quite satisfactory, but it must be conceded that the Phyllospondyli of Zittel (the Branchiosauria) do not form a group coördinate with Lepospondyli, and there is much to be said in favor of comprising the Branchiosauria, Microsauria, and Aistopoda as sub-orders of the order Lepospondyli.

The treatment of the reptiles, in which the editor had the collaboration of H. F. Osborn, S. W. Williston, J. B. Hatcher and O. P. Hay, occupies nearly one half of the book, and is admirable in details, such as the descriptions of smaller groups, but the taxonomic arrangement shows nothing of the relationships of the various orders which compose the class. It is regrettable that the revision of this section was completed before the appearance of recent papers by R. Broom, H. F. Osborn and others, which show in a convincing manner that the reptiles have had a diphyletic evolution. Some of these papers have considerably amplified our knowledge of the Anomodontia and have indicated that the Parasuchia constitute an order quite distinct from the Crocodilia.

To Mr. F. A. Lucas is due the credit for the enlargement and thorough revision of the section on birds. This part has been almost entirely re-written, and a different taxonomic scheme, based chiefly on Stejneger's classification, has been adopted, to the marked improvement of the book, although, as Mr. Lucas explains, it is not possible in the case of birds to do more than group related forms, and quite out of the question to arrange the groups so as to indicate phyletic relationships.

It will be noted that the points here criticised are all points of classification, points on which the editor and his collaborators were not entirely free to express their personal views. The translation and revision have been excellently done, and we may say that Dr. Eastman has given us in the present volume the most useful textbook published on the Palæontology of the verebrates below mammals. We trust that the volume on mammals may be as good.

J. H. McG.

BOTANY.

A New Book on Ferns.[1] — For all who study or wish to study our native ferns, Dr. Waters has prepared a book which is sure to prove both helpful and inspiring. The numerous photographic illustrations include enlarged views of the fructification in which the generic characteristics are often surprisingly well brought out. Specific and varietal differences which frequently prove perplexing to beginners are clearly shown in photographs of fronds or entire plants. Sometimes these are grouped instructively in series to exhibit the range of variation. Especially charming and significant are the views showing typical habits and habitats.

The text besides pointing out the features by which forms are discriminated, directs attention most happily to the out-door aspects of ferns — their adaptations and preferences — in a way to encourage the best sort of field work. As a help to determining specimens not in fruit the key based upon characters drawn from the stipes will doubtless prove welcome to all students of the group. While exception might be taken to such unnecessary departures from botanical accuracy as the use of "stem" for stalk or stipe, the substitution of untechnical for technical expressions has been, on the whole, skillfully done. Dr. Waters writes as a lover of ferns and his contagious enthusiasm suffuses the whole book.

F. L. S.

Porter's Flora of Pennsylvania.[2] — For sixty-five years Professor Porter was an assiduous and intelligent collector and student of the flora of the State in which he lived. A contemporary of Darlington, Torrey and Gray, he shared their knowledge and views; but he lived to see a school of natural grouping of orders, species segregation, and nomenclatorial reform, quite different from theirs, come to the front, and the editor of this posthumous Flora tells us that being thoroughly acquainted with the author's ideas he can confidently say

[1] Waters, Campbell E., Ph. D. *Ferns*: A manual for the Northeastern States, with Analytical Keys based on the Stalks and on the Fructification, and over 200 Illustrations from Original Drawings and Photographs. New York, Henry Holt & Co. 1903. 4to, xii + 362 pp.

[2] Porter, J. N. *Flora of Pennsylvania*. Edited, with the addition of analytical keys, by J. K. Small. Boston, Ginn & Co., 1903. 8vo, pp. xv + 362, with outline map.

that he would have heartily subscribed to everything in it as published. The book is essentially a list of the spermatophytes or flowering plants of the State, arranged in the phylogenetic sequence of Engler and Prantl, with keys to the orders, families, genera and species, and copious indexes to Latin and vernacular names. The nomenclature adopted is apparently based on the Rochester code, a common name is given for each species, with a reference to its description in Britton's *Manual*, and its figure, if one is published, in Britton and Brown's *Flora*,— to supplement the terse characters embodied in the keys; and each is accompanied by a brief indication of habitat, general geographic distribution, and an enumeration of the counties in which it occurs in Pennsylvania. As a determination hand-book, it is one of the best local floras thus far published. Its defect — if it be one — lies in the omission of all synonymy, leaving a very large proportion of the plants under names different from those by which they were known to the author during the greater part of his life and by which his contemporaries referred to them in their classic publications, and without intimation to the novice that this is the case or direct indication of any means by which the two may be correlated,— the Manual referred to being of no assistance in this matter.

W. T.

The Journals.— *Botanical Gazette*, February: — Darwin, "On a Self-recording Method applied to the Movements of Stomata"; Holferty, "The Archegonium of *Mnium cuspidatum*"; Lewis, "Studies of some Anomalous Dicotyledonous Plants"; Shriner and Copeland, "Deforestation and Creek Flora about Monroe, Wis."; Snow, "The Effects of External Agents on the Production of Root Hairs"; Duvel, "Preservation of Seeds Buried in the Soil"; MacMillan, "Cumaphytism in Alaria."

Botanical Gazette, March: — Garber, "The Life History of *Ricciocarpus natans*"; Merriman, "Vegetative Cell Division in Allium"; Smith, "Undescribed Plants from Guatemala and other Central American Republics — XXV"; Thom, "*Craterellus taxophilus* a New Species of Thelephoraceæ"; Greenman, "Notes on Southwestern and Mexican Plants."

Botanical Gazette, April: — Bennett, "Are Roots Aerobic?"; Nelson, "Contributions from the Rocky Mountain Herbarium — V"; Lyon, "The Evolution of the Sex Organs of Plants";

Robertson, "The Structure of the Flowers and the Mode of Pollination of the Primitive Angiosperms"; Coville, "Arcterica, the Rarest Genus of Heathers"; Ganong, "New Precision-Appliances for Use in Plant Physiology."

The *Bryologist*, March: — Fink, "Further Notes on Cladonias — *Cladonia fimbriata*"; Holzinger, "The Genus Anacolia in North America"; Cardot, "Notes on Some North American Mosses"; Collins, "Some Erroneous References"; Grout, "A New Brachythecium — *B. rivulare tenue*"; Towle and Gilbert; "The Fruiting Season of the Hair-cap Moss."

Bulletin of the Torrey Botanical Club, March: — Arthur, "Taxonomic Importance of the Spermogonium"; Harshberger, "A Phyto-Geographic Sketch of Extreme Southeastern Pennsylvania"; Cushman, "Desmids from Southwestern Colorado"; Britton, "Four new North American Birches"; and Richards and MacDougal, "The Influence of Carbon Monoxide and other Gases upon Plants, — a Correction."

The *Fern Bulletin*, January: — Parish, "The Fern Flora of California"; Clute, "Measurement of Variation in Equisetum"; Hill, "Remarks on some Fernworts of Western New York"; Clute, "A New Species of Equisetum [*E. Ferrissi*]"; Eaton, "The Genus Equisetum in North America — XVI"; Klugh, "Treasure Trove"; Fetherolf, "*Asplenium ebenoides*"; and a biographic sketch, with portrait, of Sarah Frances Price.

Journal of the New York Botanical Garden, April: — Anderson, "Protection of our Native Plants"; Rusby, "Beverages of Vegetable Origin"; and Howe, "The Pike Collection of Algæ."

Ohio Naturalist, February: — Kellerman, "Index to Uredineous Culture Experiments, with List of Species and Hosts for North America"; Schaffner, "Some Morphological Peculiarities of the Nymphaeaceæ and Heliobiæ.

Ohio Naturalist, March: — Schaffner, "Ohio Plants with Extra-Floral Nectaries and other Glands."

Ohio Naturalist, April: — Cook, "Galls and Insects producing them, with Appendix."

The *Plant World*, February: — Safford, "Extracts from the Note-Book of a Naturalist on the Island of Guam — XV"; Price, "Kentucky Oaks"; Safford, "Henry Elwood Baum (with portrait)";

Squires, "Wild Flowers of Prairie and Canyon in Northern Idaho"; Beal, "What is a Bud and how long does it retain its Identity"; Pepoon, "Destruction of a Farm Flora."

The *Plant World*, March: — Safford, "Extracts from the Note-Book of a Naturalist on the Island of Guam — XVI"; Waters, "Plant Wounds and Natural Pruning"; Blodgett, "Frost-Weeds and other Winter Notes"; Bailey, "Undraped Trees"; Britton, "Relations of Plants to Birds and Insects."

Rhodora, February: — Davenport, "Recollections of Charles Christopher Frost (with portrait)"; Ames, "*Spiranthes neglecta*"; Davenport, "Miscellaneous Notes on New England Ferns — VI"; Fernald, "Preliminary Lists of New England Plants — XIII. Juncaceæ"; Collins, "The Black Spruce in Rhode Island"; Weatherby, "*Panicum Commonsianum* in Connecticut"; Andrews, "Some Interesting Mosses from a Southern Vermont Peat-Bog"; and Ames, "*Spiranthes Grayi.*"

Rhodora, March: — Leavitt, "Partial Reversion in Leaves of the Fern-leaved Beech"; Graves, "Noteworthy Plants of Southeastern Connecticut"; Robinson, "Identity of *Anychia dichotoma*"; Rehder, Preliminary Lists of New England Plants — XIV."

Rhodora, April: — Chase, "North American Allies of *Scirpus lacustris*"; Andrews, "Bryophytes of the Mt. Greylock Region — III"; Slosson, "A New Hybrid Fern from Vermont"; Sanford, "The Range of *Saururus cernuus* extended into R. I."; Harger, "Some Introduced Plants of Ct."; Nye, "Bulblets of *Microstylis ophioglossoides*"; Knight, "*Cleome serrulata* in Me."; Graves, "*Helenium nudiflorum* in Groton, Ct."; and Osmun, "Further Stations for *Botrychium matricariæfolium* in Ct."

Torreya, February: — Stone, "Physiological Appliances — II"; Arthur, "An interesting unpublished Work on Fungi"; Britton, Juncaceæ of the West Indies"; Britton, "*Agdestis Clematidea*"; Harper, "New Station for *Arabis Georgiana*"; Burnham, "Notes on *Epigæa repens*"; and Atkinson, "A New Lemanea from Newfoundland.

Torreya, March: — Osmun, "A Summer in Salisbury, Ct."; Sumstine, "The Slime-Mounds of Pennsylvania"; Eggleston, "The Cratægi of Ft. Frederick, Crown Point, N. Y."; Britton, "*Cratægus Porteri.*"

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